

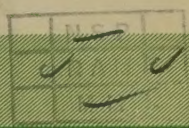
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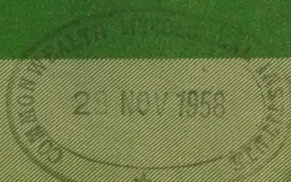
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QUARTERLY REVIEW

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NO. 41 AUTUMN 1958

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REVIEWS AND ABSTRACTS

In this section of the N.A.A.S. Quarterly Review, it is intended to survey current research and experiment in agriculture, horticulture and the allied sciences applicable to the work of the National Agricultural Advisory Service. It will not be possible, of course, to cover more than a small part of this wide field in each issue.

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The Veterinary Investigation Service

H. I. FIELD

Veterinary Investigation Centre, Cambridge

IN A PAPER which he contributed to the Quarterly Review in 1953,* my colleague, Mr. D. W. Menzies, gave an outline of the work of the veterinary investigation service and discussed some of the problems that were at that time under investigation. It is interesting and instructive to read his paper again after an interval of five years, because from it one can assess both the progress that has been made and the new problems which have arisen.

The investigation service is, of course, only one branch of Animal Health Division. Some of the major diseases of farm livestock are primarily the concern of the field staff and do not normally fall within the purview of the investigation service. Other problems are dealt with by the research staff in the central laboratory at Weybridge. However, the different branches of the division—field staff, central laboratory and investigation service—collaborate closely in certain fields, although each has its own particular problems and interests. Each branch takes a proper pride in the achievements of the others. The investigation service for example, will share the reflected glory of the field staff for what will perhaps be their greatest achievement: the eradication of tuberculosis in cattle, a struggle which started in 1935 and of which we can now see the end. While this paper is mainly concerned with the work of the investigation service, it should not be forgotten that the other branches of Animal Health Division have their own problems, which they tackle in their own way. But all branches of the service have a common objective: to safeguard the health of the nation's livestock.

It would be impossible in the space at my disposal to discuss more than a few of the diseases that were being investigated in 1953 or which have subsequently come to light. This review will therefore be confined to a consideration of problems affecting cattle and pigs.

Cattle

HYPOCUPROSIS

Copper deficiency in cattle was first reported in Great Britain in 1946, and the disease has subsequently been studied in considerable detail. By 1953 we knew that it occurred, either clinically or sub-clinically in most parts of the country. Extensive experiments had shown the effects of deficiency on growth and production. Analyses in various

*The Veterinary Investigation Service. *N.A.A.S. Quart. Rev.* No. 20, 1953, pp. 329-36.

parts of the country confirmed that the pastures grazed by copper-deficient stock contained enough of the element to meet the physiological requirements of the animals, a finding which suggested that some other factor in the herbage was interfering with the utilization of copper; in other words, that it was a "conditioned", rather than a true, deficiency.

It was already well known from Australasian work and from studies on the teart pastures of Somerset that molybdenum was one element which, in excess, could interfere with the assimilation and storage of copper by ruminants. More recent studies have shown that in parts of East Anglia there is an inverse relationship between the copper and molybdenum contents of pastures. The copper content of herbage was found to be at its lowest at the period of maximum growth, that is, in the spring months, while at this time the molybdenum content was at its highest. It is nevertheless known that molybdenum is not the only factor that interferes with the absorption and storage of copper. Other elements may have a similar effect, and an experiment recently completed at an investigation centre suggests that one of these elements may be iron. Other experimental work on this problem is being carried out at the central laboratory.

Although it has been shown that copper deficiency can be prevented in a variety of ways, the search continues for a simple method that can be applied under most conditions of husbandry. Methods that have previously been tried with success include the top dressing of pastures with Cu SO_4 —either alone or incorporated in fertilizers, the periodic oral dosing of deficient cattle, intravenous administration of copper or the feeding of a specially compounded cake containing Cu SO_4 . More recently, attempts have been made to prevent and cure deficiency by the intramuscular injection of copper glycinate. This is a relatively simple procedure which can be readily done under most conditions of management. The early results of this work are promising.

The need to confirm copper deficiency by blood and, preferably also by liver analyses, before attempting therapeutic or preventive treatment, cannot be over-emphasized. Even when a diagnosis has been established, the amount of copper to be given or applied must be carefully assessed if unfortunate results are to be avoided. The animal needs minute amounts of copper to maintain it in health. If it does not get enough to meet its needs the effect is serious, but if it gets too much the effect may be disastrous. Far too many cattle, sheep and pigs have died in this country during the last few years from a too enthusiastic use of copper—often given to animals which were not deficient.

BRACKEN POISONING

Five years ago, work on bracken poisoning of cattle had reached a stage where it was clear that bracken contained a toxic substance which could be inactivated by heat. This earlier work was carried out

at the Aberystwyth centre in collaboration with staff of the University College of Wales. The chemist and physiologist of the team was Dr. Charles Evans, who has subsequently been appointed to the chair of Agricultural Chemistry in the University College of North Wales, Bangor. Here he has continued his studies on bracken in collaboration with the staff of the Bangor Veterinary Investigation Centre. Their work has been directed along two lines; firstly, the extraction and identification of the toxic factor and secondly, the treatment of clinically affected cattle. The staff of the investigation centre have been concerned mainly with the latter aspect of the problem.

Bracken poisoning causes characteristic changes in the blood of cattle, notably a fall in the number of white blood cells and platelets. This fall is associated with a bone marrow lesion which closely resembles that produced by X-irradiation. Workers in the human field reported in 1954 that treatment with a substance called di-batyl alcohol produced a striking response in patients suffering from irradiation leucopenia. Other workers found that when the substance was given to mice which had been subjected to total body X-irradiation it increased the survival time. As irradiation and bracken poisoning have similar effects on bone marrow, it seemed likely that di-batyl alcohol might have some beneficial effect in cases of bracken poisoning. The treatment of experimentally produced and field cases of the disease shows this to be so. Field trials to confirm the preliminary findings have been arranged for this summer.

MASTITIS

There were high hopes a few years ago that the marked reduction in the incidence of *Str. agalactiae* infection, following the extensive use of penicillin, would result in the virtual elimination of mastitis as a herd problem. This has not proved to be so, and mastitis continues to be a problem, although on a reduced scale. But the problem is no longer one of udder infection so much as one of udder injury. If a sensitive tissue is abused, its function is impaired. That is what is happening in many herds in the country at the present time. Investigations have shown that most herd mastitis problems nowadays are due to indifferent milking machine technique. The commonest error is to leave the units on the cows after the quarters are empty.

VIBRIOSIS

The study of vibriosis is mainly the concern of the central laboratory at Weybridge and of the Ministry's A.I. Centres at Reading and Ruthin. This genital disease of cattle is transmitted by the bull at mating and all the evidence obtained in early studies showed that once a bull became infected it remained infected, and therefore capable of transmitting the disease, probably for life. The great advance in this field has been the demonstration by workers both at Weybridge and the A.I. centres, that infected bulls can be successfully treated.

HUSK

Some notable advances have been made during recent years in our knowledge of husk, particularly in the field of prevention and treatment. Workers in one of the veterinary schools have evolved a method of immunization which is extremely promising, while extensive treatment trials on experimentally infected calves carried out during the last few years at one of the investigation centres are also encouraging. The drug used in these trials was diethylcarbamazine, which was originally used for the treatment of certain blood parasites of human beings.

What of the new problems? Perhaps the most important disease of cattle which has come to light during the last few years is so-called *mucosal disease*. As its name implies, this disease affects mucous membranes, mainly those of the alimentary canal but also, to a less extent, of the respiratory tract. It is probably better to call it the mucosal disease complex, for there are several different clinical syndromes that go under the name of mucosal disease. The probability is that they are due to different, if related, viruses. Diseases falling into the mucosal disease complex have been recognized in the U.S.A. for some years. A similar disease was diagnosed for the first time in this country in 1954, since when it has made its appearance in several parts of Great Britain. Mucosal disease affects cattle of all ages, although young animals appear to be more susceptible. Infection has been successfully transmitted at the central laboratory, and the disease is at present being studied intensively as a collaborative effort between veterinary investigation officers and the virology department at Weybridge.

Pigs

It is probably true to say that more time and effort has been devoted by the investigation service during the last few years to a study of the causes of morbidity and mortality in pigs than at any previous period in its history. There are many reasons for this. The pig industry has expanded enormously and the value of pigs has shown a corresponding increase. This expansion is reflected in the number of pigs sent to investigation centres for examination and in the number of requests to investigate outbreaks of disease on farms. This in turn has brought to light some new diseases and has led to intensive research on others.

SURVEY OF PRE-WEANING MORTALITY

Surveys carried out in various parts of the world show that with pigs most losses occur before weaning. This has been amply confirmed in surveys carried out by the investigation service during 1955-57 inclusive, which showed a pre-weaning mortality rate in the survey herds of approximately 25 per cent. For the purpose of the survey, arrangements were made to determine the causes of death by laboratory examination, and the results were recorded on specially designed

punched index cards. The survey is being continued until this autumn and the results, when analysed, should give a more accurate picture of the causes of pre-weaning mortality than has hitherto been available.

ENTERITIS

It was already clear at the end of the first year's survey that enteritis was one of the major problems occurring in the pre-weaning stage. As a result, a special field and laboratory study of outbreaks was carried out at one investigation centre. This showed that there were many different causes of enteritis. A few outbreaks had features in common with an infectious and transmissible form of gastro-enteritis (T.G.E.) which has been recognized for many years in the U.S.A. This form of enteritis is now being studied in one of the veterinary schools.

ABORTION AND STILLBIRTHS

The first year of the survey also showed an unexpectedly high incidence of abortion and stillbirths, and as a result, another member of the service made a special field and laboratory study of these problems. His work has shown that in some herds the two conditions occur together, while in others losses may be due almost entirely either to abortion or stillbirths. It seems clear that the number of stillborn piglets increases progressively with the size of the litter; thus the stillbirth rate is significantly higher in the numerically larger litters. There is a suggestion (which needs to be confirmed) that this increase is associated with the time taken to give birth and that if this could be shortened the stillbirth rate would fall accordingly. Only a few of the losses from these causes were found to be due to infections. Occasional outbreaks were associated with vitamin A deficiency in the sows. These observations are being continued.

OEDEMA DISEASE

This is one of the important causes of deaths in "newly-weaned" pigs, a term which in 1953 referred to pigs over 8 weeks of age but which nowadays may often apply to piglets a few days old. To be more explicit, before the introduction of early weaning, oedema disease occurred mainly in pigs between 8 and 12 weeks old. Since the introduction of early weaning, it not uncommonly occurs in pigs under 8 weeks old. The earlier studies of this disease showed that it could be reproduced experimentally by the intravenous injection of intestinal contents from affected pigs. Subsequent work, carried out mainly by Weybridge workers in collaboration with investigation centres, has shown that it is associated with infection by haemolytic strains of *E. coli*. The disease has been reproduced experimentally by the injection of extracts of certain strains of this organism. Thus the stage is reached where the final solution of this problem, from the etiological point of view, is in sight.

"TALFAN" DISEASE

Nervous disorders in pigs, often characterized by partial or complete paralysis, are quite common. The name "Talfan" disease has been given during the last few years to a paraplegic condition which usually affects fattening pigs. The incidence within a herd may reach quite serious proportions. Outbreaks of this disease have been encountered by investigation officers in several parts of the country. Material from these outbreaks has been sent to the central laboratory at Weybridge, where the research workers have established that the disease is due to a virus infection. The story does not quite end there. One of the important diseases of pigs in eastern Europe is called "Teschen" disease, and although there are certain differences between the clinical syndromes of Teschen and Talfan respectively, there are no apparent differences between the causal viruses.

One could continue to write about pig diseases for a very long time. It is almost certainly true that during the last ten years more new or previously unrecognized diseases of pigs have been brought to light than of any other species of farm livestock. Is this any real advance? Quite obviously it is, because the better the veterinary surgeon or investigation officer is able to identify the different clinical conditions which he meets, the more valuable the advice he can give to the farmer.

Soil Structure*

E. CROMPTON

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OUTCROPS of solid rock on the earth's surface are exposed to the shattering effects of heating and cooling, or freezing and thawing, and to further pulverizing during erosion and transportation by wind, water or ice. The rock is reduced to fragments of various sizes which at first have no order or arrangement other than that imposed by the mechanism of deposition. The pedologist recognizes a size range of fragments including boulders, stones, gravel, sand, silt and clay. In the laboratory he concerns himself mainly with the fine earth which will pass through a 2 mm sieve, and this he subjects to a mechanical analysis to determine the proportions of coarser and finer material. The International Scale recognizes four grades with approximately the following

*A lecture given at the District Agricultural Officers' Refresher Course, West Midland Region, January 15, 1958.

particle sizes:

Coarse Sand	...	2 mm to 0.2 mm
Fine Sand	...	0.2 mm to 0.02 mm
Silt	...	0.02 mm to 0.002 mm
Clay	...	Less than 0.002 mm

The sand and silt particles consist mainly of fragments of rock material, and the divisions between them are largely arbitrary, although there is a tendency for the silty particles to be more platy in character, a feature which often applies also to the finer portion of the fine sand. Indeed, there is a good deal of practical evidence that the American division at 0.05 mm forms a more satisfactory distinction between fine sand and silt.

Clay is very different in character from the larger soil fractions. It consists of two main kinds of particles: (a) the silicate lattice minerals, and (b) the hydrous oxides. The *lattice minerals* consist of three main groups:

- (a) 1. The first group, the *kaolin materials*, may be illustrated by kaolinite which is built up of flat units, each consisting of one silica sheet and one alumina sheet tightly bound together by mutually shared oxygen atoms. Each flat unit is rather firmly attached to the next one by oxygen-hydroxyl linkages. There is little possibility of expansion, and water or cations cannot normally move between the units. Kaolinite crystals form hexagonal units of relatively large size.
2. The *montmorillonite group* is represented chiefly by the mineral montmorillonite which is composed of flat units containing 2 silica sheets with 1 alumina sheet firmly held between by mutually-shared oxygen atoms. The units are rather weakly held to each other, are easily expandable, and water and cations can readily pass between. The particles are very much smaller than in the kaolin clays.
3. The *illite group* is rather like montmorillonite, but the units are bound to each other by potassium ions which lie between them, and illite is therefore less expandable than montmorillonite, and in most properties lies between that and kaolin.
- (b) The *hydrous oxides*, mainly iron and aluminium, are of great importance in some soils, particularly some of those of tropical countries. Their colloidal properties are much less marked than those of the lattice clay minerals, but they have a marked stabilizing effect on soil structure.

A result of the extreme smallness of clay particles generally, and of the internal surfaces lying between the units, is the enormous surface area presented by clay material. The clay contained in a typical furrow slice on a single acre has a total surface area many times larger than the whole of Great Britain. Considerable quantities of water can be absorbed on these surfaces, lubricating them so that the clay particles slide over each other and the clay becomes very plastic. On drying, the films of water become thinner, the clay shrinks and the particles are bound so closely together that the clay becomes hard and brick-like. The properties of moisture absorption, expansion, shrinkage and cohesion are naturally most marked in the montmorillonite clays, and decrease in intensity through the illite, kaolin to hydrous oxide groups.

Various cations are absorbed on the clay surfaces, and they affect the condition of the clay. Where sodium is present in any quantity, the clay particles tend to keep separated from each other or in a dispersed condition, in which the colloidal properties are most marked. When calcium is dominant the clay particles tend to clump together in the condition known as flocculation which, as will be seen later, has important effects on soil structure. Although the mechanism is not fully understood, the hydrous oxides of ferric iron and aluminium produce a much more marked flocculation even than calcium.

Organic Matter

All soils contain organic matter, varying in amount from negligible quantities in hot deserts to complete dominance in the purely organic soils of waterlogged sites. The organic material is derived, of course, from the decomposition of plant and animal remains, and the degree of decomposition varies from fresh litter and root material to the completely amorphous "humus" which is intimately combined with the mineral portion of the soil. This highly decomposed humus is colloidal in character and exhibits the properties of moisture and cation absorption to a much greater extent even than the clay, but it is only slightly plastic and cohesive. Moreover, very small amounts of this humus may drastically modify the plastic and cohesive properties of the clay.

Development of Soil Structure

The process of soil development on a newly exposed surface such as the floor of a recently drained lake illustrates the mechanisms by which soil structure develops. If the material contains a large percentage of clay the shrinkage due to drying will produce a roughly hexagonal pattern of cracks perpendicular to the drying surface, and so a system of vertical fissures appears. This effect is particularly marked in uniform, highly dispersed clays and silty clays, especially those rich in exchangeable sodium, and the cracks may extend to considerable depths. As a vertical fissure widens, a new drying surface develops in the fissure itself and may thus promote the development of horizontal cracks, or cracks at various angles resulting from the complex combinations of drying surfaces.

Rapid re-wetting causes new strains due to unequal expansion and to pressure from entrapped air, and further fissuring develops, especially near the ground surface. At greater depths the wetting and drying is generally slower, strains due to sudden expansion and contraction are less severe, and the cracks often remain mainly vertical.

Beginning with a material such as lake mud, therefore, the purely physical processes of drying and re-wetting change the uniform mass into isolated blocks separated by cracks and cavities of various sizes, shapes, and orientations. It seems to have been this complex pattern of both cracks and solid material which was originally termed soil

structure; just as a house consisting of rooms and cavities of various shapes and sizes separated by brick walls may be said to possess structure, whereas the heap of bricks from which it was built has none.

Structural Units

The stability of any structure depends on the stability of the solid portions, and partly for this reason, and partly because solid objects are easier to handle and describe than a system of cracks, attention has been concentrated on the aggregates. The pedologist uses three sets of terms in which to describe them:

- A. First he describes the extent to which soil structure is apparent, in the field and then by laboratory measurements. A soil may be structureless, like a dune sand or a puddled clay, or it may be weakly-, moderately- or strongly-structured.
- B. Secondly, the pedologist considers the shape and size of the soil aggregates. Here again he faces the common difficulty that there are no very obvious divisions, and he must either have numerous precisely-defined categories or he must use a few simple distinctions, and expect many examples to fall between them. The broad divisions now in common use are:
 1. Units with the vertical axis longer than the horizontal one. These are subdivided into:
 - (a) *Prismatic*, in which the tops are flat or pointed.
 - (b) *Columnar*, in which the tops are rounded.
 2. Units with the horizontal axis longer than the vertical are described as *platy* or *laminated*.
 3. Units with axes roughly equal are either:
 - (a) *Blocky*, which is further divided into *angular* and *sub-angular*. (*Granular* is a common term which seems to refer to very small sub-angular, almost rounded, blocky aggregates.)
 - or (b) *Crumb*, which is a term used for a very porous, small aggregate, in ideal form looking rather like a bread crumb.

Together with an indication of size and the recognition of compound units, a fairly clear picture of the structural features of a soil can be conveyed in the above terms.

- C. Structural units of the same shape and size may vary a great deal in their stability under different conditions. Terms such as plastic, hard, tenacious, friable, mellow, loose, etc., represent the farmer's attempts to describe the behaviour of the soil in its reaction to cultivation. The pedologist may use the same terms, attempting to define them a little more precisely, or he may make rather more precise estimations both in the field and in the laboratory. For instance, the fact that water is the force most disruptive of soil structure has led to the widespread use of a laboratory technique in which a soil is gently agitated in water in a series of sieves which gives a measure of stability of aggregates of various sizes.

The structure of a soil should, therefore, be described in terms of: (A) grade or degree of structure, (B) shape and size, and (C) stability of soil aggregates. With these concepts in mind it is now possible to describe more of the processes involved in soil structure development.

Further Structure-forming Processes

It has already been seen that drying and wetting can produce prismatic, blocky, and perhaps platy aggregates. Freezing also affects soil structure: *slow freezing* leads to the formation of relatively few larger ice crystals growing in some of the soil cavities, and by their growth exerting pressure on the soil aggregates around them, so increasing their cohesion and stability; *rapid freezing*, on the other hand, causes ice to form in the numerous water-filled cracks and tends to disrupt the soil into a multitude of very small fragments.

Plant roots ramify through the soil, opening up fissures and exerting pressures both mechanically, by their growth, and through the drying of the soil immediately around them. The very fine granular and crumb structures so common in the rooting zone, particularly of grasses, owe much of their fineness and porosity to the mass of fibrous roots in which they are enmeshed.

Creatures of various kinds are active in the soil, enlarging the cavities through which they move, and often stabilizing the aggregates by substances which they excrete. Earthworms are the most effective, both through their burrows, which form continuous channels for the movement of air and water, and by their casts, which form small and remarkably stable aggregates.

So far, consideration has been given chiefly to the "external" forces affecting soil structure. The nature of the soil material itself is also a major factor. The kind of clay primarily affects the extent to which the soil shrinks and expands. Because of their great changes in volume due to drying and wetting, montmorillonite clays tend to form well-developed aggregates, prismatic in the subsoils, especially those low in organic matter, but often granular in the surface soils. Illite is somewhat similar, but does not fissure so readily, whilst kaolin tends to behave rather differently. It is said to encourage the formation of laminated structures which could be the result of the relatively large size of the platy kaolin particles, which tend therefore to behave rather like silt. In many soils in which kaolin is the dominant clay mineral, hydrous oxides are also abundant, and they seem to encourage granular and even crumbly structures of great stability. This is at least partly due to their flocculating effect. Although flocculation is not the same as granulation or crumb formation, it seems to encourage it—perhaps by decreasing the cementing effect which is most marked in clays shrinking from a dispersed condition. Calcium-saturated clays are also generally well-flocculated and therefore tend more easily to form granular and crumb structures.

But the major modifying effects are the mechanical composition of the soil material and the amount and nature of the organic matter. Soils consisting almost entirely of sand particles cannot form structures, and their consistence remains loose. Those composed mainly of clay vary very widely, but due to their great capacity for shrinkage and

cohesion on drying they may be capable of forming fine granular structures. Soils which contain a considerable amount of silt and fine sand and only small amounts of clay are amongst the most poorly structured. The clay is sufficient to bind the rigid sand and silt particles together on drying, but is not sufficient to provide the shrinkage necessary to open up distinct fissures, or to protect the coarser particles against the erosive effects of water. Silt soils therefore run easily when wet, and set in an extremely hard mass when dry. Alternate wetting and drying seems to produce lamination which further reduces permeability, often to a negligible level.

The addition of coarse plant fragments to the soil, either naturally as root residues or deliberately, may affect the total porosity and aeration without immediately increasing the proportion or stability of soil aggregates. It seems, however, that both the mechanisms of decomposition and certain of their products can have a marked effect on aggregation and stability. Fungi are often important agents in decomposition, and soil particles may be bound together mechanically by fungal hyphae. The decomposition of both plant fragments and fungal hyphae by bacteria seems to involve the production of dark gummy substances which may coat and protect the soil aggregates, and some organic products seem to become firmly absorbed on the surfaces of the clay particles, modifying their stickiness and plasticity.

There is a good deal of evidence suggesting that many of these structure-stabilizing products of organic decomposition are short-lived and any long-continued effect depends on a continuous supply of organic matter and continuity of decomposition. It also seems that the decomposition must occur under aerobic conditions such as exist in freely-drained soils. In fact, Hunter and Currie have shown (*J. Soil Sci.*, 7, 1) that even short periods of waterlogging may break down the organic stabilizing materials and lead to structural collapse, a process which tends to be self-accelerating as structure collapse itself leads to poorer aeration.

Soil structure formation is, therefore, a complicated process involving a wide variety of factors and is as yet most imperfectly understood.

Importance of Good Soil Structure

Plants must have an active root system to absorb from the soil the moisture and nutrients necessary for growth. This implies a moist soil with sufficient air-filled cavities to enable the roots to respire, to take in oxygen and give off carbon dioxide. The amount of carbon dioxide normally contained in the soil atmosphere may be produced by the roots in one hour during the active growing season, and if gaseous exchange with the atmosphere above ground is restricted the CO_2 may reach toxic levels in a very short time. In practice, diffusion is restricted mainly by waterlogging, and to maintain adequate aeration it is necessary to have some relatively large and continuous fissures

through which water can drain freely, and which will remain partly air-filled or will empty quickly after rain. These larger channels are also necessary if rainwater is to be conducted into the soil and the moisture supply to the roots maintained. Too-close packing in the surface promotes excessive run-off, reducing the moisture supply to the soil, and perhaps provoking soil erosion.

In coarse-sandy soils no aeration difficulties arise; even with the closest possible packing the cavities between the sand grains are large enough to maintain free drainage. If fine-textured materials are closely packed, however, the cavities are all small and remain filled with water held by capillarity. In such soils, larger cavities depend upon soil structure formation in which even if the particles remain closely packed within the aggregates, air-filled fissures occur between them. The growth of most plants on heavy soils depends, therefore, on soil structure, and its maintenance is one of the major concerns in soil management.

Effects of Farming on Soil Structure

As long as the soil remains under a continuous cover of vegetation structural difficulties rarely arise. The soil is not heavily attacked by disruptive forces such as the impact of raindrops, and the growth and decay of roots provides a perpetual supply of new fissures. But farming generally involves first the clearing of the land, perhaps from virgin forest. The soil immediately becomes subjected to the direct force of rain on the surface and probably to the more rapid movement of water over it.

Ploughing and cultivating, which generally follow, bring some direct mechanical disruption to the soil aggregates and open them still more to the atmosphere. This greatly reduces the numbers of soil fauna, particularly earthworms, and by increasing the aeration promotes oxidation, and reduction in amount of organic matter. In some soils in which subsoil drainage is dependent on deep vertical fissures, ploughing, particularly if it is deep, may shear and seal the top of the fissures and lead to slower drainage and even waterlogging in the topsoil. Before the initial ploughing the soil structures are so well stabilized that the soil remains granular or crumbly, perhaps through several cropping seasons, the period varying enormously according to soil type. Ultimately, however, it is clear that the process of cultivation must tend to disrupt soil structure, and the more frequently the soil is cultivated the more destruction there is likely to be.

In coarse sands the process is of concern only if the levels of organic matter fall to the point of a deficient moisture capacity, or if it leads to blowing of the sand particles, which can generally be cured by marling. In clays, the signs of deterioration are an increasing tendency to be sticky when wet, and hard when dry; in other words, there is a narrower moisture range over which the soil is friable. In soils of wide texture

range, particularly those high in silt and very fine sand, evidence of structural deterioration is seen in the increasing tendency of the soil to run together and cap on the surface, and for the fractions to separate out, the sand particles glistening on every micro-elevation, and the silt and clay running down into each little depression or hoof mark. A common feature, too, is for the surface layers to appear laminated or brick-like, without obvious pores or fissures. When this stage is reached on pasture the grass roots are often rust-coated, indicating temporary surface waterlogging, even where the subsoil is well drained. Again, such a process tends to be self-perpetuating; it leads to the anaerobic destruction of the humic structure-binding substances, to the flowing and close-packing of soil particles and to further waterlogging.

In a similar way, a good structure tends also to be self-perpetuating in that it helps to maintain the aerobic conditions necessary to form the right kind of organic matter for structure stabilizing. It is evident, therefore, that great care should be taken to maintain existing good structure as it is far more difficult to recover once it has been destroyed.

Preservation of Structure

In farm practice the most desirable structure is to be found under well-managed, old pasture, and every farmer knows the ease with which good grassland breaks down to a friable crumb or granular tilth after ploughing. Poor grassland may not be so good; a surface mat presents its own difficulties, and the structure of the soil beneath the mat is generally weak and collapses easily after ploughing. The excellence of the structure of good grassland is associated with a good calcium status, a well-distributed root system, high biological activity including a large earthworm population, and a high content of well decomposed organic matter having a carbon/nitrogen ratio of about 10 or 11. Professor Walker has recently been drawing attention to the tendency for the organic matter in good grassland to have a C:N:S:P ratio of approximately 100:10:1:1. Instances have been recorded in New Zealand where deficiency of sulphur is the limiting factor, but most commonly phosphorus is the main requirement. In the British Isles sulphur deficiency has not yet been recorded, but phosphate deficiency is widespread, and shortage of lime is perhaps even more generally limiting. However this may be, it is quite clear that unless a soil is adequately supplied with the necessary nutrients, including especially lime and phosphate, neither good grassland nor the good structure associated with it can be maintained.

Although the soil structure of old pasture is certainly ideal, there are some arable soils with much harsher structures which continue to produce excellent crops. Residues from both grain and root crops restore considerable quantities of organic matter to the soil, and as their roots decay they leave channels and pores for drainage and aeration.

Other soils, however, are difficult, and special care is necessary if satisfactory structure is to be maintained.

The first requirement then in the maintenance of good structure, is to be sure that crops are well supplied with the necessary nutrients. But these same nutrients also stimulate the agents of decomposition such as bacteria, and unless a sufficient supply of fresh organic matter is assured, there is little chance of retaining a good soil structure. Under continuous arable cropping, on some soils at least, the necessary amounts can only be provided by large additions of farmyard or green manure, which often appears to have a better aggregating effect when incorporated into the surface than when ploughed under. Even so, there are circumstances in which a new supply of fresh palatable food seems so to stimulate bacterial activity that they renew their attacks on existing soil organic matter and the final level is actually lowered.

It is generally recognized that a grass break is the only practicable method of maintaining and restoring soil structure on the average farm. On sandy or light loam soils, two or three years in grass may restore the structural condition to that of an old permanent pasture on the same soil. On some heavy-textured soils, however, the period required may be more than 50 years, and to be effective in restoring a lost structure, leys would need to be very long indeed! But leys must be well-managed, and on difficult soils they may need to be used with the welfare of the soil foremost in mind, rather than the crop or stock. On a young ley there is a considerable area of bare soil exposed to the beating of the rain and to puddling by hooves. On fine-sandy and silty soils, especially those low in organic matter, the surface soon packs and seals, and the anaerobic conditions produced by a mere shower of rain are likely to prevent the production of stabilizing organic products. The effect is seen at its worst on some opencast coal sites where permeability is so low that water stands for days after a single shower, whilst the soil an inch below it may remain dust dry.

On soils with a poor structure, or a natural tendency to structural instability certain principles should be observed:

- (a) Ample nutrients should be provided.
- (b) The soil should be kept covered as much as possible. Sowing a quickly establishing cover crop with leys might be expected to reduce surface sealing in the establishment stage.
- (c) Mowing rather than grazing should be the policy in the first year, and also in subsequent years in the worst cases. The grass should be mown at the stage expected to give maximum root development.
- (d) Applications of farmyard manure probably help the leys, both by providing a steadily available nitrogen supply, and by providing a stimulus to the build-up of the earthworm population.
- (e) When the land is cultivated the plough should be kept within the surface layer of granular structure. The lower layers almost always show less stable structures which flow and pack more easily. With deep ploughing there is also the tendency to seal off the deeper subsoil cracks and to produce waterlogging in the surface.

- (f) Cultivations other than ploughing should be carefully timed and kept to a minimum.

Conclusions

It should be clear from this discussion that soils are extremely varied in their structural properties. Practices which are perfectly sound on some soils can be disastrous on others. There is urgent need for both a complete soil survey and the follow-up which should define clearly a soil's properties, and, perhaps most of all, its structural condition and behaviour. Those responsible for research and advice should learn to recognize their soils, should get to know their eccentricities and "personalities", and should make sure that any advice they give is applicable to the particular kind of soil.

Farm Management Advice—The Group Approach

E. S. CARTER

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SINCE the appointment of Farm Management Liaison Officers with the Provincial Agricultural Economics Service, there has been considerable interest in the dissemination of advice on farm management matters and topics of farm economics. The general pattern that has emerged is that the National Agricultural Advisory Service usually gives this advice in the first instance, relying on the Provincial Agricultural Economics Department for standards and interpretation of data. The farmer's first approach, therefore, will be through the District Advisory Officers of the N.A.A.S., who have local knowledge of the farmers and type of farming. The fact that they have an agricultural background, and are not economists, is probably an advantage when talking to farmers who often feel that advice from an economist will be theoretical rather than practical.

The farming community is generally aware of the value of such aspects of the advisory service as soil analysis, information and data on new varieties, and so on, but farmers are unlikely to come forward with their economic problems unless they are first aware of the type of service that is available. Clearly, the N.A.A.S. must "sell" to the farming community the idea that its officers are capable of doing this work, and are able to provide something of value. Personal contact is a slow method of achieving this, although it has many undoubted advantages. The best chance of getting these ideas over to the farmers fairly rapidly seems, therefore, to be through group meetings.

It is often suggested that it is not possible to deal with a subject such as farm management on a group basis. Many feel that as a farmer's accounts and finance are confidential matters, any attempt to discuss them in public must be regarded with suspicion. In the U.S.A., however, where economic advice is an accepted part of the Extension Service, group methods of dealing with the problem have been in operation for some years with apparent success, and the possibility of dealing with farm management on a group basis in Britain has already been demonstrated by the successful work that has been done in some counties, particularly Cornwall.*

Two Trial Classes

That this method can be successful when dealing with larger farms is shown by the response in parts of Lincolnshire, where, during the winter of 1957-58, a number of groups were formed in Lindsey to deal with farm management problems. Work with these groups has followed different patterns and brought out a number of points which may be useful in formulating a similar approach in other parts of the country. The groups covered farms of different sizes, and farming practice varied from one to another, so that a wide range of problems was covered.

The first meetings were held as evening classes arranged by the local education authority with instruction given by the N.A.A.S. The extra-mural organizer for the County Farm Institute at Riseholme, when arranging the programme of evening classes for farmers, suggested that two of these might deal with farm management. A syllabus was prepared and eventually two such evening classes were arranged. The membership of one class was open to all, but no attempt was made to persuade any particular group of farmers to attend, and the class could be regarded as unselected since farm size ranged from 20 or 30 acres up to 300. The second, although also open to all, was predominantly made up of a group of farmers whose farms averaged about 100 acres, with intensive arable cropping, and who were invited by the L.E.A. from a list drawn up by the local district advisory officer.

Both classes can claim to have been a success, but there was a greater response from the second one. Quite clearly there was an advantage to be gained from a selected audience with common interests and farms of a similar size; the discussion interested all the farmers all the time since their problems were mutual; furthermore, they tended to speak more freely before one another.

Arising out of the obvious value of these meetings and the interest shown by the farmers, requests were received that something similar should be done in other localities, and two N.A.A.S. "Study Groups" were formed. At both of these the members were invited by the local district advisory officer, bearing in mind the type of farming, size of

*The Group Approach to Farm Management Studies. R. S. BOYER, *Agricultural Review*. 2, No. 7, 19-23.

farm, etc. One of these groups covered farms ranging in size from 200 to 1,500 acres with an average of around 600 acres. The type of farming was arable with some livestock, and all the farmers attending were at the top of their class in technical efficiency. The second group covered small farms on rather heavy land where arable farming with dairying was practised.

A further group was formed dealing with dairy farms on an area of sand land. These meetings did not deal exclusively with farm management as the study of farm accounts, but developed into a discussion group concentrating on a study of the economic and management factors of small dairy farms. This proved to be successful, and the farmers concerned definitely found the discussion and exchange of views of considerable value. This group is to continue with farm walks during the early summer to relate the winter discussions to farm practice.

The Basic Pattern

All the talks and the meetings followed the same pattern. Originally, at the evening classes five meetings were considered to be necessary, but with the study groups it was found that where the audience was specially invited, three meetings were sufficient. Whatever the number of meetings, an introductory talk was devoted to pointing out the value to be obtained from an analysis of the farm business, and this was followed by a detailed explanation of the analysis of a set of accounts. An "example farm" had to be obtained for this purpose, and the example used had, of course, to throw up some points which would illustrate the value of the method. At the first meeting, a request was made for members of the group to bring forward their own accounts for analysis; it was pointed out that there would be more advantage gained from an analysis of a local farm than from an example brought from outside, and that, of course, when the figures were presented to the group they would be confidential and no one in the room would know to which particular farm they related. There was an immediate response to this and sets of accounts were handed in at all the groups. In fact, at one group, five sets of accounts were offered for analysis. At the final meeting the analysed accounts were presented to the group, points made from the analysis, and the members asked to raise any questions or to put forward their own suggestions for the future running of the farm, or criticisms of the present organization. This proved to be particularly valuable and many interesting and useful points were brought out by the farmers themselves.

At the last meeting, the method of partial budgeting was also outlined to show how an assessment could be made of the effect on farm income of changes in cropping, etc. This involved a discussion about fixed and variable costs, and it was not at all easy to convey this concept to farmers, especially those keeping cost accounts for each crop.

It is, of course, difficult to assess the value of meetings of this nature. The farmers concerned were interested at the time and went out of their way to express their appreciation of the meeting and the fact that the N.A.A.S. was prepared to deal with economic aspects of farming and not just technical matters. There has been an increase in requests for farm management advice, not only for a complete analysis of the business, but to discuss organization of labour, changes in cropping, etc. The district advisory officers concerned are convinced that the meetings have been of value, and are considering co-operating with the L.E.A. in forming similar study groups during the winter of 1958-59. They are all satisfied that these groups serve a useful purpose in stimulating interest in farm management and in helping to throw up special problems of organization within the group.

Although it has been suggested that larger farms with a high level of technical efficiency are unlikely to respond to this type of advice, it is emphasized that the meeting where the average farm size was 600 acres was probably the most successful of the whole series. It may well be that the changed economic circumstances and the possible uncertainty in farmers' minds regarding the future has made them more ready to accept the idea that there is value in this type of advice, but whatever the reason they are ready to discuss costs and their relation to output.

Criteria for Future Groups

To be successful, farm management meetings should consist of small groups of farmers—not more than 25 in number, who have a common interest in type of farming and farms of nearly the same size. The members of the group should be well known to one another and there should be a leader who has the respect of all. In any group there is always a farmer who can act in this capacity and whose acceptance of new ideas stimulates others to try them. Selection of the members of the group is obviously important and it is here that the district advisory officer's local knowledge is of great value. Some personal canvassing may be needed, but all members should receive written invitations before the first meeting setting out briefly the object of the meeting and the programme.

The speaker should deal with the subject from the practical aspect right from the start, and as little time as possible should be devoted to theoretical concepts. It is here that local knowledge is important, and the ability to relate the subject to farming systems practised by the group and to draw on local problems is a great asset. Some facts and figures which the audience can apply to their own farms will stimulate interest and show that the subject is not something concerned with "averages" but can be linked to practical farming. It is in this connection too that the analysis of sets of farm accounts from members of the group, followed by discussion, is of such value. Although the

farms concerned remained anonymous throughout our meetings, the figures were so similar to those relating to other farms in the group that individuals were able to compare them with their own farms. This gave greater value to the resulting discussion. Since a wide variety of topics—by no means confined to economics and farm management matters—were discussed, the speakers must be prepared to deal with all the points raised even in general terms.

These notes may be of value to others planning a similar approach to the subject in areas where farm management advice is not yet generally accepted by farmers. The next step would seem to be to continue with successful study groups and to examine special aspects of farming systems in more detail.

ACKNOWLEDGMENT

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Reviews and Abstracts

Trace Elements and Grassland

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SUCH a prodigious number of publications on trace elements has appeared in the last few years that it is now a long job to find out the relevant information on any special aspect. In particular, details of amounts of fertilizer recommended and successfully used are scattered about among a large number of papers in a variety of journals which are often not readily accessible to field workers.

This review, while not claimed to be comprehensive, collects together information of use to grassland workers in this country who are concerned with the investigation of known and suspected nutrient deficiencies. The major nutrients nitrogen, phosphorus, potassium and calcium are not considered, since it is assumed that readers are sufficiently familiar with the effects of deficiencies of these elements. The only major nutrients considered are magnesium and sulphur, whose importance has been rather neglected in the past, but more attention is given to the so-called trace elements—manganese, zinc, copper, boron, molybdenum and cobalt.

General Principles

All the above-mentioned elements except cobalt have been shown to be essential for plants, and there is some evidence that even cobalt may be necessary for some plants. Grasses are less demanding in their quantitative requirements than most other crop plants, and there are few recorded cases of their responding to boron and molybdenum, but legumes are rather more sensitive than many other crop plants to deficiencies of these two elements, which are consequently as important in grassland associations as the remaining trace elements. These trace elements, except boron and molybdenum, are also essential for animals. In grassland practice, therefore, the needs of both plants and grazing animals must be considered. If a deficiency affects grazing animals but is not severe enough to affect the plants, it is probably easier and cheaper to remedy it by provision of mineral licks, or by adding minerals to supplementary feedingstuffs or to water supplies, than to apply them to the soil; on the other hand, it may not always be practicable to provide licks, particularly where sheep are concerned (see also [7]). If a deficiency is severe enough to affect the plants, then obviously it must be remedied by supplying adequate amounts of the deficient nutrient in a form available to the plants.

Availability is important, because a "deficiency" may be due either to an inadequate amount of the element in the soil, or to its presence in adequate amount but unsuitable form. Manganese, for example, may be present in quite high concentration and yet be unavailable to plants because it is in a too highly-oxidized state, while iron may be unavailable because it is not sufficiently oxidized. Copper may be present, in organic soils, in a chelated form in which it is unavailable. Generally speaking, trace elements are more likely to be in an available form if the soil pH is low (acid) than if it is high, so liming on acid soil is more likely to aggravate deficiencies than to relieve them. The exception to this is molybdenum, which is more available under neutral or alkaline conditions than acid ones. This is not to suggest that liming is a bad thing except where molybdenum deficiency occurs—some acid soils produce manganese toxicity, which is reduced by liming.

Nutrients may be applied either solid and dry, as major nutrient fertilizers usually are, or in solution. The latter method is more often used if a deficiency is caused by unavailability, or where the crop concerned would be sprayed anyway (e.g., fruit trees). Spraying, or applying solution from a watering can is quite practicable on small plots, and is safer and more accurate than applying dry fertilizers, which might be blown about, but it is probably not an economic proposition on grassland on a field scale. Fortunately, conditions in this country are usually such that ordinary dry application is quite satisfactory.

Rates of application are important, because while it is necessary to apply sufficient fertilizer, it is equally important to avoid excess,

which can easily cause toxicity to plants and even to animals. The rates quoted below give some idea of the range of amounts which have been used, although often only on experimental plots and not on a field scale.

Recommendations

The rates quoted by Hudson and Cradock [12] as being recommended by Anderson should prove satisfactory for a plot trial to assist or confirm diagnosis. If a deficiency is confirmed, further trials with larger amounts of the deficient elements can be made if it seems that better yields are possible. The rates given are stated to be "levels which have given good responses, in most cases lasting for several years without further treatment". However, these rates were worked out for conditions in Australia, where plant deficiencies are often the results of complete, or almost complete, absence of the element from the soil.

The "Anderson technique" consists in laying out plots—the suggested standard size is 3 yd \times 14 yd—and applying to them various combinations of fertilizers. Alternate plots are controls receiving all nutrients, so that comparison with other treatments is easier; the remaining plots each receive all nutrients but one, each being omitted in turn. The advantage of this method over applying each one alone is that multiple deficiencies will be demonstrated if they occur—and it is more usual to find a multiple deficiency than a simple one.

Details are as follows:

Material	Rate per Acre	Amount per Plot
Lime	2 cwt	(3 yd \times 14 yd = 1/115th acre) 2 lb
Superphosphate	10 cwt	10 lb
*Molybdenum trioxide	1 oz	4 grains (heaped on a sixpence)
Borax	3½ lb	½ oz
Potassium sulphate	1 cwt	1 lb
Copper sulphate	7 lb	1 oz
Zinc sulphate	7 lb	1 oz
Manganese sulphate	14 lb	2 oz
Magnesium sulphate	56 lb	8 oz

*1½ oz of sodium or ammonium molybdate will supply approximately the same amount of molybdenum in available form.

If sulphur deficiency is suspected, 25 lb per acre (4 oz per plot) of flowers of sulphur are recommended as an additional treatment, with and without superphosphate. It is also suggested that on acid soils a strip 2 yd wide be superimposed across all treatments and limed at 1 ton per acre. To keep the nutrients to the proper plots mixing with damp sawdust is recommended.

The rates of application of lime and superphosphate are questionable under our conditions; very few agricultural soils in this country would

need as much as 10 cwt per acre of superphosphate, while far more than 2 cwt of lime might be needed. The rates suggested by Wallace [21], though intended for fruit or vegetable crops rather than for grassland, seem more appropriate.

Wallace's recommendations are as follows:

<i>Material</i>	<i>Rate per acre</i>
Superphosphate . . .	4 cwt
Ground limestone . . .	according to acidity
Magnesium sulphate . . .	4 cwt
Potassium sulphate . . .	2 cwt
Borax	20 lb
Manganese sulphate . . .	20 lb

Wallace's scheme does not include copper, zinc or molybdenum, since deficiencies of these had not been definitely confirmed at that time as occurring naturally in this country.

The following brief summary, arranged under elements, illustrates the ranges covered in various experiments.

BORON

Powers and Jordan [16] reported that not more than 20 lb per acre of borax could be applied to sensitive crops (potatoes, tomatoes, beans) without risk of toxicity, but that 30-50 lb might be applied to tolerant ones (including lucerne); they also give details of how to counteract effects of excess boron. Anderson [1] found that $3\frac{1}{2}$ lb per acre of borax successfully counteracted deficiency in lucerne and subterranean clover.

COPPER

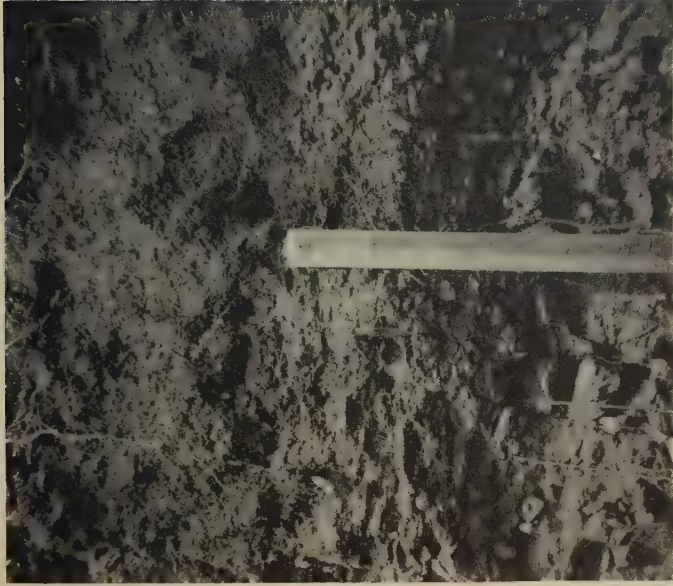
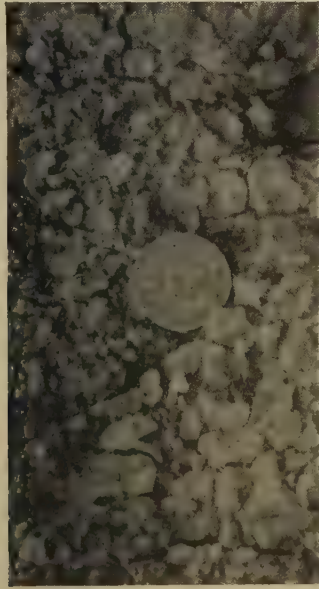
Cunningham [8] advised the use of 5 lb per acre of copper sulphate in autumn; Anderson (cited by Powers and Jordan) recommends 7 lb: Teakle [19] found maximum responses from 5-10 lb ($2\frac{1}{2}$ -5 lb on sandy soil), while Lucas [14] successfully used 100 lb on an organic soil.

COBALT

Askew [3] found that 4 oz per acre of cobalt sulphate gave satisfactory results, though it was better to apply it in two doses of 2 oz each than in one dose. Cunningham [7] recommended 5 oz of cobalt sulphate per acre per annum, and also said that in New Zealand top dressing was a more economical way of supplying cobalt and copper than mineral licks. Brouwer [5], in Denmark, used 2 kg per hectare of cobalt chloride.

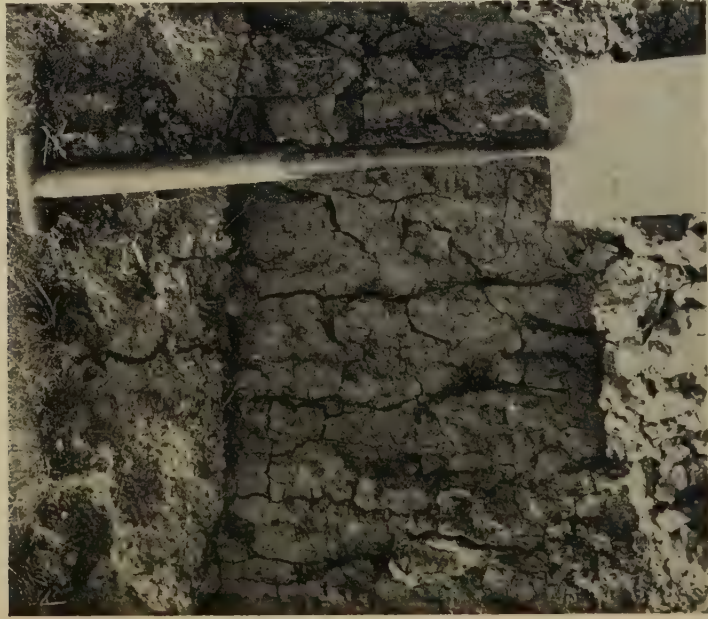
MAGNESIUM

Magnesium deficiency seems rarely, if ever, to have been confirmed in pastures; when hypomagnesaemia occurs in cattle it seems to be caused by their inability to absorb or mobilize magnesium rather than by dietary deficiency (Russell and Duncan [18]). Apart from the recommendations of Anderson (56 lb/acre) and Wallace (4 cwt/acre)

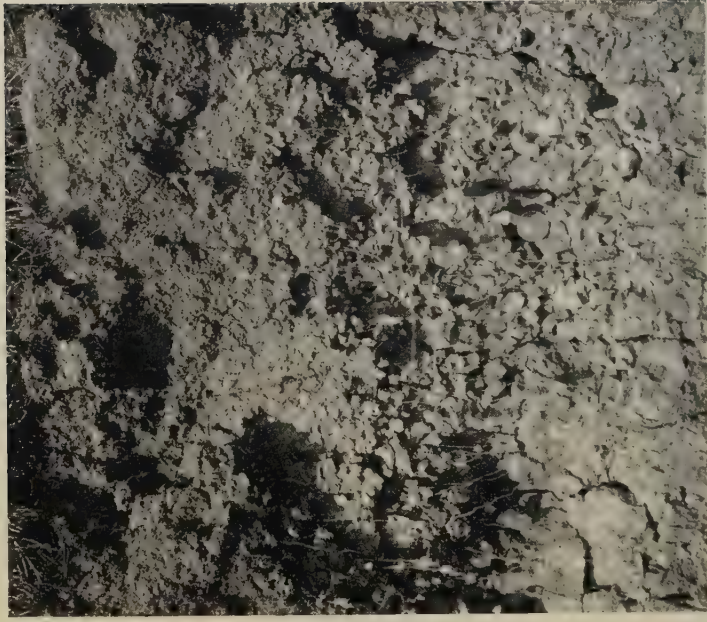


Top: Angular blocky structure.
Bottom: Crumb structure.

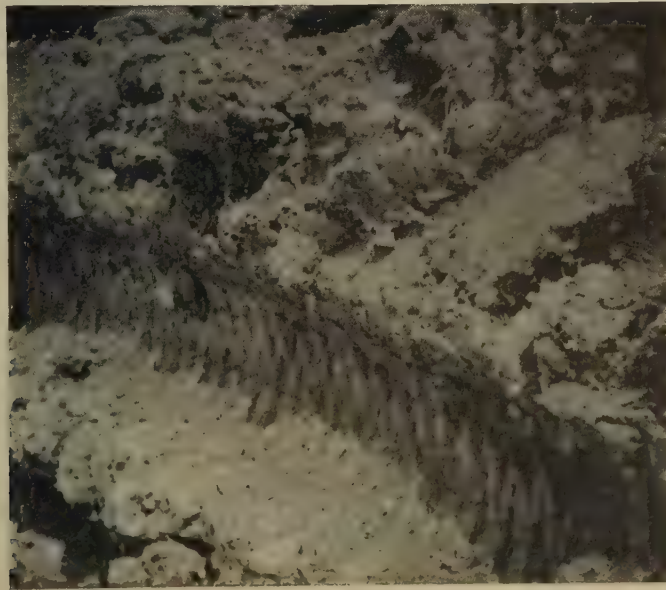
Surface soil: Weak crumb structure.
0-2½ in. on ruler: Platy structure.
Below 2½ in.: Angular blocky structure.



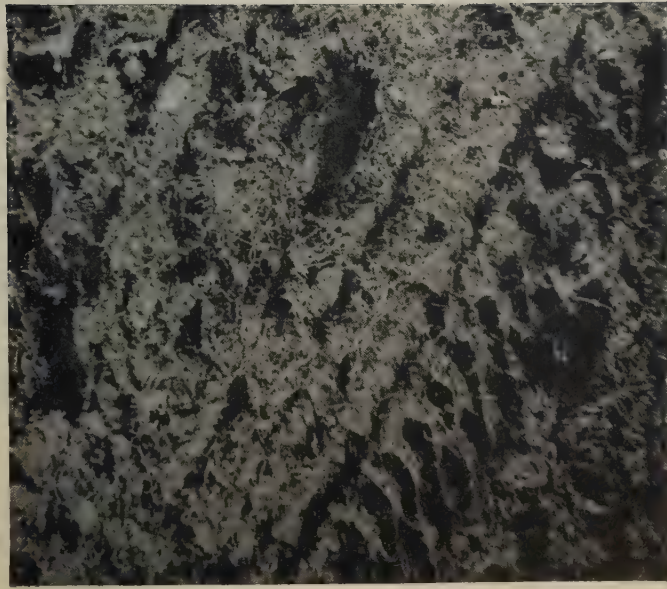
Prismatic structure.



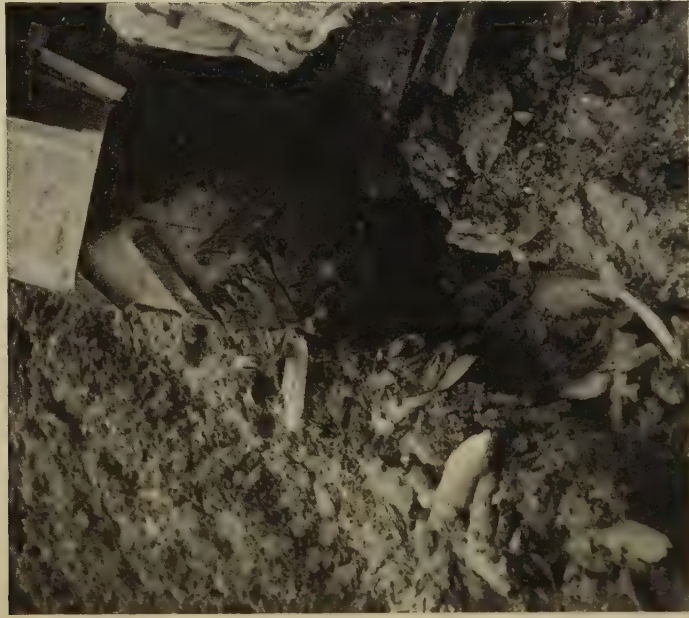
Fine sub-angular blocky structure at surface, becoming angular blocky in centre, and tending to prismatic below.



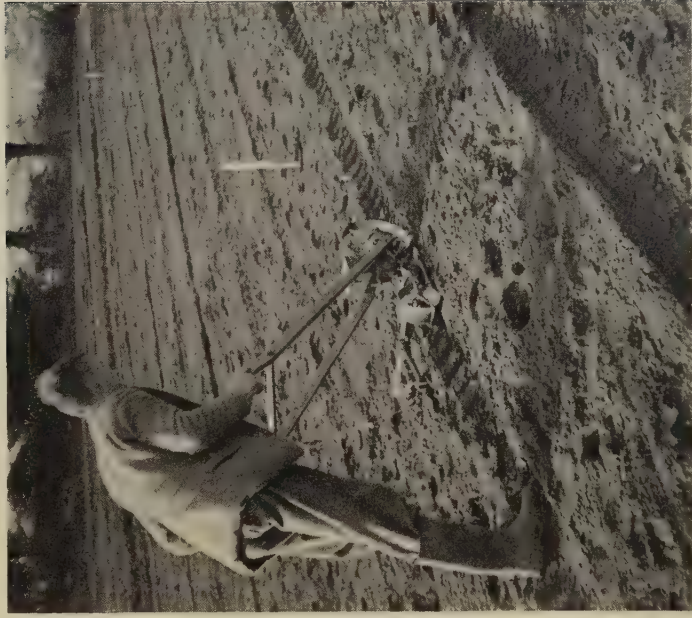
Trough, with smeared track pattern, made by slipping tractor tyre.



Sharp-patterned track made by a tractor tyre gripping well into very soft soil.



This tractor was pulling a heavy load. Flexing of the tread bars of the driving wheel tyre caused mud to exude from between the bars in compact rolls of soil, but left the tyre clean and able to grip.



Experimental drilling of seed in the track left by a heavily ballasted pneumatic-tyred tractor, for comparison with drilling in the uncompressed soil alongside the tracks.

already quoted, most of the recommendations in the literature are for the use of dolomitic limestone to replace all or some of the lime which would be applied to the acid soils on which deficiency is likely to occur.

MANGANESE

Mulder and Gerretsen [15] quoted rates of 50-100 kg per hectare of manganese sulphate as being recommended by various authors: on alkaline peats more may be necessary. However, manganese deficiency is often due to conversion of manganese to unavailable oxides, so that spraying with 0.2 to 0.5 per cent solution (500-1000 litres per hectare) is more effective and often more economical. The addition of acidifying substances such as sulphur (flowers of sulphur) or ammonium sulphate, or of acid peat often increases availability of manganese already present. On organic soils, Conner also recommends the addition of sulphur (500-1000 lb/acre), or 100-200 lb per acre of ammonium sulphate, as an alternative to an application of 60-100 lb of manganese sulphate [6].

MOLYBDENUM

Anderson [2] in a review of the subject, says that in Australia and New Zealand, 2 oz per acre of sodium or ammonium molybdate are generally adequate and that 1 oz would probably be sufficient, although very occasionally more is needed. High levels of sulphate, iron, or manganese, or low soil pH or phosphate, increase requirement. One application should last ten years.

Lobb [13] found $2\frac{1}{2}$ oz per acre adequate in more than 50 trials. He also recorded responses of grasses to molybdenum. Cunningham and Hogan [9] refer to "the usual rate of 2 oz per acre".

SULPHUR

Sulphur deficiency has been confirmed in Australia. Hilder [11] reports that 64 lb per acre of sodium, magnesium or calcium sulphate gave a large increase in yield, though 80 per cent of this increase was given by 30 lb dressings. Superphosphate gave responses due entirely to the sulphur content. It seems unlikely for such an extreme deficiency to be found that the amount of sulphur in superphosphate if applied at the usual rates, would be inadequate to relieve it.

ZINC

Dunne and Elliott [10] found that subterranean clover could not be established on a sandy soil newly cleared of timber without the addition of 4 lb per acre of zinc oxide or $5\frac{1}{2}$ lb of zinc sulphate. Riceman [17] reported good establishment of sown pasture in soils to which 7 lb per acre of zinc sulphate had been applied the previous year. Barnette and Warner [4] recommended 20 lb per acre for corn, while Viets, Boawn and Crawford [20] successfully used 23 lb per acre of zinc sulphate on various species, including white clover and lucerne.

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Farm Management

Planning the Farm to Save Labour

It has been estimated that in this country livestock account for about 50 per cent of the time spent in farm work. Most of this time is spent in buildings because stock at grass need little attention. It is apparent, therefore, that labour saving in and around buildings is a subject of importance.

In a recent study, Sturrock and Brayshaw [1] have examined labour routines in milk production and in the feeding of yarded cattle and young stock. Apart from milking and one or two other special operations, feeding, littering and cleaning account for approximately 80 or 90 per cent of a stockman's time. Most of this work is drudgery and should be reduced to the minimum possible by simplifying, and if possible eliminating, the transport of materials. So far as possible each group of livestock should have its own stores of materials which should be delivered from the field or by outside transport to the point of use. Furthermore, if it is necessary to have a central store, e.g., for mixing concentrate rations, it is best to have a secondary store in the livestock building. Transport by tractor and trailer can thus take place at weekly or longer intervals.

A survey of labour requirements for yarded cattle illustrated the need to apply these principles on farms. More than five times as many man-hours were required to tend the same number of stock on some farms as on others, and most of the variation was due to layout and methods of management. Indeed, it was found possible to predict, fairly accurately, the number of man-hours required from a knowledge of the distance travelled by the stockmen, the weight of materials handled and (in the case of fodder) the number of times fed. Of these factors, the distance walked by the stockman was the most important.

In addition to the need to store bulk foods where they are to be used, three other factors which reduce labour requirements for yarded cattle are:

- (a) placing food troughs so that they can be filled without entering the yard;
- (b) having an automatic piped water supply; and
- (c) mechanical cleaning of yards. If the yard is littered, at least 25 ft of the fence should be removable.

The report commended four basic designs of yards, three of which were the most adaptable and generally useful. The merits of each and their possible variants were discussed, and details of methods of feeding stock were also given.

Accommodation provided for calves on many farms was criticized. Some calves are housed in small lots in boxes scattered around the farm. On other farms, the "calf pens" are makeshift erections of a few hurdles tied with string standing in the corner of a barn. They are often troublesome to open, difficult to clean and draughty. The cost of providing a

well-designed calf house is small in comparison with that of a cowhouse and would often be a sound investment. Not only would it save much labour but the calves would thrive better. The main requirements for saving labour in calf rearing are that:

- (a) Calves should be grouped together and close to the cowhouse from which milk or suckling cows are brought. If the farmer is in the habit of buying calves or young stock, it may, of course, be prudent to put new animals in an isolation box for a period in case they are carrying infection.
- (b) There should be room for food preparation and storage in the calf house. It is an advantage to have a small water heater.
- (c) There should be a feeding passage and brackets to hold the pails while the calf is feeding. It should be possible to put the milk pail in place without entering the calf pen. Feeding troughs for older calves should also be filled from the feeding passage.
- (d) Very young calves should have individual pens if possible. They need not then be tied after feeding to prevent them from sucking each other.
- (e) Although feeding is by far the most important item, care should also be taken to make cleaning as easy as possible.

The same principles of reducing material-handling time were applied to the design of cowhouses. The dairy should be placed as close as possible to the cowhouse. If the house is small or medium in size (say up to 40 or 50 cows) it is not important whether the dairy is at the end or the middle of the house. But for larger cowhouses there is an appreciable saving of labour if the dairy is placed in the middle of the house. Bulky foods should be stored as near as possible to the cows, and the drudgery of removing manure should be reduced to a minimum.

What Slows Down Milking?

Labour requirements for milking were studied in detail. In a survey of 61 farms, individual milking rates varied from 8-50 cows per man-hour. Where rates were too low, the chief faults were:

- (a) Inconvenient layout.
- (b) Too many, or too few machines.
- (c) Too much time spent machine-stripping.
- (d) Sharing of work between cowmen. It is almost impossible to divide the operation of milking between two men to give equal tasks. As a result, one wastes time waiting for the other. Men working as a team seldom achieve speeds much above 12 or 15 cows per man-hour.

Details are also given of variations in building design and working routines which may be suitable for individual farms. In view of the need to reduce labour requirements for livestock and the current interest in these problems, this report from Cambridge can be highly recommended for both advisers and farmers.

Beef Cattle on the Arable Farm

A survey of the economics of beef production on arable farms has been

reported by Butler and Simpson [2]. Information was collected from more than 70 farms in the Wolds, Holderness and Vale of York areas in 1954-5 and 1955-6, and the 60-page report provides useful material on most of the economic aspects of beef production.

The cheapest calves were those reared by the more intensive forms of multiple suckling and by bucket rearing with the use of milk substitutes—the average costs ranging from £38 for single suckling on in-wintered cows to £24 for bucket rearing with milk substitutes. There are certain periods when store cattle are relatively expensive to keep and others when they can be kept cheaply. The expensive periods are the initial calf period—usually costing from £25 to £30, and the winter periods in yards—costing in the region of £20. The cheap periods occur during the summer when cattle cost only between £3 and £5 for a grazing period of about 6 months. Therefore the total cost of rearing to any particular age is greatly influenced by the relative numbers of cheap and expensive periods chargeable to the cattle. Thus, at 18 months both autumn- and spring-born cattle have charged against them two expensive periods (initial calf period and one winter period) and one cheap summer period, and at this age their costs were identical at about £51 7s. 0d. At 24 months, however, there was a wide difference in the cost of autumn- and spring-born cattle (costs of £55 10s. 0d. for the former and £72 5s. 0d. for the latter). These relative costs at different ages are an important factor to be taken into account in deciding on the most profitable time for sales.

Improving Efficiency in Pig Production

The overwhelming importance of feed costs in pig production makes the relation between feed cost and output of pigs a crucial factor which largely determines profits. Following a survey of methods of pig production in southern England, Thornton [3] has discussed some of the measures of efficiency of production which can be applied quite simply on many farms. On the fattening side, the feed conversion rate may be fairly easily determined, but before drawing any conclusions from the conversion rate for any farm the following factors should be considered:

1. The conversion rate tends to decrease as the pigs increase in size. Thus, for herds producing mainly pork pigs, a fattening conversion rate of 3.4 lb of meal per lb liveweight gain may be regarded as a reasonably good performance, whereas in herds producing mainly bacon pigs, a conversion rate of 3.8 would be equally good;
2. Rations vary widely in their nutrient content; and
3. The conversion rate will be adversely affected if the mortality rate among growing pigs is particularly high.

Unfortunately, the report did not discuss methods by which feed conversion rates could be improved. It was pointed out, however, that the farmers with the lowest feed costs per ton were generally those who bought in large quantities at the most opportune time and milled and

mixed their own rations on the farm. The importance of low conversion rates and low feed costs was illustrated on the farms in the survey: the cost of adding 1 lb live weight to growing pigs in the five least efficient herds was nearly twice as high (17d.) as in the five most efficient herds (9½d.).

A primary objective of the producer is to reduce feed costs on the breeding side also. But useful standards for feed consumption and unit feed cost are more difficult to establish because breeding stock requirements vary widely according to breed and living conditions. In the report, a number of standards were included against which various aspects of the breeding process may be measured, e.g., farrowings per sow per year, number of pigs reared per litter, mortality, feed per sow and feed cost per sow. However, there is no optimum level of performance for all producers. The breed of pig kept, the land available, the quality of farrowing quarters, time available to the pigman, and many other factors, influence the standards reached. It is a question of reaching the highest standards possible with the available resources on the farm.

In a recent article in *Pig Farming*, Ridgeon [4] of Cambridge considered in more detail the feed requirements for fattening pigs and on information available, discussed whether heavy pig production would increase or decrease the profitability of a pig enterprise. His task was complicated by the lack of data in this country relating to feed conversion rates at various stages of fattening—an example of one of the major problems facing farm management advisers at the present time. Before the profitability of any enterprise can be calculated, it is necessary to know the physical relationship between the inputs (e.g., feed and labour) and the output of product (e.g., pigmeat). There appears to be a dearth of husbandry experiments designed to produce such information, and until such material is available, farm management advice will continue to rely heavily on broad assumptions and rough estimates.

By adjusting Danish figures to suit conditions in East Anglia, he calculated that the overall feed conversion rate (including an allowance for the sow) declined until a pig is 185 lb live weight, after which it increases, but only slightly at first. He showed that the average feed cost per lb liveweight gain declined up to 230 lb live weight. On a deadweight basis, the food cost per lb continues to decline when the pig weighs more than 260 lb live weight.

At that weight the total quantity of food required, including that required for the weaner, amounts to just over 10½ cwt, costing £14 16s., at an average price of about 28s. per cwt. Other costs of production amount to about £3 per pig, making a total cost of £17 16s. for producing a heavy pig of 260 lb live weight which, killing out at 78 per cent, is equal to 10 score 3 lb dead weight. A change of 1s. per cwt in the price of feed made a difference of 10s. 6d. per pig in production costs. Comparing this cost with recent pig prices showed average profits per pig

varying from £1 15s. to £3 10s. according to the price ruling at time of sale.

On the basis of the assumptions and calculations made by Ridgeon, heavy pig production appears to be worthwhile for those farmers whose bacon pigs fail to obtain satisfactory gradings but are able to convert inexpensive feed to meat quite efficiently. Fattening such pigs for sale at 260 lb live weight by continuous *ad lib.* feeding may at present be a quicker and better alternative to introducing new stock in an attempt to improve gradings. However, any farmer contemplating a change to heavy pig production may be well advised to negotiate a contract in advance to protect himself against any possible oversupply in the market.

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K.D.

Mycology

Bitter Rot of Apples Caused by *Gloeosporium* Spp.

Bitter rot of apples is not a new disease; as long ago as 1924 Kidd and Beaumont [1] recorded a rot of apple fruits caused by *Gloeosporium album*. This fungus was noted by Ogilvie [2] as a frequently occurring saprophyte on pruning snags in orchards. In 1943 Wilkinson [3 and 4] reported, for the first time in Britain, a fruit rot due to *Gloeosporium perennans*. He also found the same fungus causing branch cankers in a Warwickshire orchard which was summer pruned. Recently both fungi, but particularly *G. perennans*, have caused serious losses in fruit stores. The increasing importance of this problem may be at least partly due to the fact that now more fruit is being stored for longer periods.

Different workers have investigated the problem from various angles. In an orchard at Long Ashton, Corke [5 and 6] has studied the canker phase of the disease by inoculating shoots of 'Cox's Orange Pippin' at monthly intervals with both mycelium and spores of *G. album* and *G. perennans*. He found that *G. album* seldom invaded shoots successfully and never formed actively sporing cankers. With *G. perennans* mycelial

inoculations were successful throughout the year. On the other hand, there was considerable seasonal variation in the results obtained with spore suspensions of this species. The most successful inoculations were those made during the winter months and from these cankers were produced which continued to grow until the following autumn. In the few successful inoculations made during summer the cankers were rapidly cut off by callus tissue; acervuli occurred on cankers of all ages almost throughout the year and produced viable spores from May to December. From these results Corke concluded that pruning in the autumn was most likely to encourage infection.

Canker Removal

There is some conflict of opinion on the feasibility of reducing infection caused by *G. perennans* by cutting out the cankers. Hunnam, Bagnall and Bennett [7] compared trees pruned normally with those in which all visible cankers had been carefully removed. After one season they found that the vigorous removal of cankers had no effect on the number of fruit rots occurring in storage. They also found that the following season the trees from which cankers had been carefully removed still carried up to 5 per cent of the number of cankers present in the first season. However, Hamer found that stringent cutting out of cankers for three successive seasons reduced the losses of stored fruit from 80 per cent to 25 per cent [8]. Edney [9 and 10] has also pointed out that cankers are not the only sources of infection in the orchard. He found that many dead snags of wood on the trees carried *G. album* or *G. perennans*, and frequently this fungus followed woolly aphis damage. The latter fungus was also found on dead detached leaves in orchards after picking time.

Rots in Stored Apples

Edney [10] has also studied intensively the factors affecting development of rots in stores. The greatest losses occurred in 'Cox's Orange Pippin', but considerable damage also occurred with 'Laxton's Superb', 'Worcester' and 'Bramley's Seedling'. Although 'Cox' was the most susceptible variety, great variation occurred from season to season, even with apples of this variety from the same orchards. The rots started to develop at the lenticels, which if impermeable to gaseous exchange resisted penetration of the fungus. With 'Cox', resistance to infection declined with length of time stored, but the date of onset of rots varied considerably in samples of apples from different commercial orchards. Rotting occurred even at temperatures as low as 0° C, but was most rapid at about 20° C. Storage in an atmosphere of 3 per cent oxygen and 5 per cent carbon dioxide reduced the amount of rotting. Another interesting feature of this disease is reported by the Ditton Laboratories [11] and Montgomery [12]; apples produced in grass orchards tend to be more resistant to rotting in store than do those from cultivated

plantations. Marsh and Edney [13] also suggested that grassing down may have been a factor in reducing *Gloeosporium* attack on fruit in a plantation of 'Allington Pippin' at Long Ashton.

Spraying Reduces Rot

A number of workers have made attempts to reduce *Gloeosporium* fruit rots by spraying. Marsh, Montgomery and Edney [14] reported that in a preliminary trial in 1953 on 'Allington', two applications of either 0.1 per cent captan or 0.2 per cent ziram reduced rots in fruit stored until January 18 at 37° C from 66 per cent to approximately 30 per cent. In the same orchard in 1954, single sprays of 1 per cent captan applied on either August 16 or September 22 were compared with two sprays applied on both dates. Although all treatments achieved some reduction in rots, the double application was the most effective, giving 18 per cent rots compared with 41 per cent in the unsprayed controls. A similar trial was carried out the following year, and although the incidence of the disease was much lower, two sprayings on August 30 and September 17 were again better than a single application on the latter date. Marsh and Edney [13] continued these experiments in 1956, when they compared the effects of a single spray on September 18 with two sprays on August 21 and September 18, and three applications on July 18, August 21 and September 18. The disease was again at a low level, and no effect of spraying was apparent until the fruit had been stored until February, when the fruit receiving two and three applications showed significantly less rots than those receiving one or no sprays. In a final examination on March 6, only the treble application showed any reduction in rots: 4.8 per cent compared with 8.4 per cent in unsprayed controls.

Trials with 'Cox's Orange Pippin'

Following the preliminary trial on 'Allington Pippin' in 1953, trials were carried out by Marsh, Montgomery and Edney [14] in five commercial orchards in Kent and two in Sussex in 1954 on 'Cox's Orange Pippin'. Two high-volume sprays of 1 per cent captan were given, the first between August 4-9 and the second between August 19-27. Samples of apples were stored until March 31. Although the results varied from site to site, except at one centre where fruit was not picked until late October, the sprays achieved a significant reduction in *Gloeosporium* rots. Over all the trials the mean percentage rots of sprayed fruit was 9.7 per cent, compared with 21.4 per cent unsprayed. In another trial on 'Cox' at Kirdford, Sussex, the results were partly vitiated by much of the fruit being cracked, but again two captan sprays gave some measure of control.

Hamer and Hunnam [15] have reported further results obtained on 'Cox' at Kirdford. In 1955, three captan sprays applied in July, August and September were more effective than two sprays on the first two

dates, or one spray on the first date. After storage for 151 days, the rots found at two centres were as follows:

1955	No. of Rots	
	<i>1st Centre</i>	<i>2nd Centre</i>
THREE SPRAYS		
July 27, August 8, September 10 . .	19	9
TWO SPRAYS		
July 27, August 8	36	18
ONE SPRAY		
July 27	45	25
UNSPRAYED CONTROL	37	31

The following year similar trials were made, except that the earlier applications were omitted from the "one" and "two-spray" treatments. After storage for 140 days at 38°-39° C, the percentage rots recorded were as follows:

1956	No. of Rots	
	<i>1st Centre</i>	<i>2nd Centre</i>
THREE SPRAYS		
July 26, August 16, September 6 . .	10	23
TWO SPRAYS		
August 16, September 6	10	28
ONE SPRAY		
September 6	23	48
UNSPRAYED CONTROL	38	50

Thus, in this trial there was little difference in result between two and three applications, but single spraying was relatively ineffective.

LOW-VOLUME SPRAYING

Because of the practical difficulty in getting high-volume machines through some orchards during the period July to September, Hunnam, Bagnall and Bennett [16] carried out experiments in 1956 to test the possibility of using a low-volume motorized knapsack sprayer and duster. In one trial, the rates of application per acre were 150, 50, 20 and 5 gal of suspensions of captan and captan dust. In each case, the concentration of captan applied was adjusted to give $2\frac{1}{2}$ lb of active material per acre. In two other trials only high volume (150 gal per acre), low volume (5 gal)

and dust were given. In all three trials three applications were given with each treatment, in late July, mid-August and early September. All the treatments reduced the amount of fruit rotting from one-half to one-third of that in the unsprayed controls. There was no significant difference between high- and low-volume sprays and dust, though at one centre dusting was almost significantly inferior to spraying.

Attempts were made to reduce rotting by dipping fruit in 1½ per cent captan suspension after picking. Although some reduction in storage rots occurred in two trials, no success was obtained in two others.

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H.E. Croxall

Poultry Husbandry

Quality in eggs is important to encourage the public to consume the increased output at prices satisfactory to both producer and consumer. In the U.S.A., the reported decline in egg production over the last few years has also stimulated a drive to improve egg quality from the consumer's viewpoint. A number of articles recently published dealing with aspects of the important subject of egg quality, have, therefore, some topical interest.

Re-assessing Egg Faults

Quality grading of eggs has been carried out for many years, and the down-grading or rejection of eggs is still largely based on categories of egg faults drawn up many years ago. It now seems debatable whether all the "faults" detected by candlers are of any great moment—and conversely, whether increased attention ought not to be given to other conditions hitherto disregarded or looked upon as of minor importance. A paper on "Blood Spots" by L. D. SANBORN, C. MILLER and G. F. STEWART (*Poultry Processing and Marketing*, 1957, **63**, 18) suggests that consumers are far less critical of blood spots and meat spots than is generally assumed by packers. The same survey also queries whether the consumers' judgment of the age of eggs is reliable, and if they do place so much stress on the proportion of thick white as is generally assumed.

A rather interesting note on this last point is entitled "Mechanisms of Shell Egg Deterioration: comparisons of Chicken and Duck Eggs" by M. B. RHODES and R. E. FEENEY (*Poultry Sci.*, 1957, **36**, 891-7). The authors found that duck eggs were much more resistant than hen eggs to the deteriorative thinning of the thick white and yolk membrane. Moreover, ammonia gas did not lead to the same rate of deterioration in duck eggs as in hen eggs. (This may be of some importance in this country in view of the popularity of deep litter housing.) Chicken and duck eggs have closely similar compositions although there are minor but important differences in the structure of the whites. A closer study of this subject, therefore, seems to be worthwhile, in the hope that hen eggs could be produced by selective breeding with whites more resistant to breakdown. A paper on the associated subject—"Relationship of Selected Egg Quality Measurements" by G. J. MOUNTNEY and C. VANDERZANT (*Poultry Sci.*, *ibid*, 908-13) gives an account of the relationship between various egg quality characteristics. These workers found that only a close relationship existed between specific gravity and shell thickness and specific gravity and shell weight. Rather surprisingly, no correlation was found between shell weight and interior quality.

One characteristic of the egg shell about which little is known is that condition known as "mottled". A substantial amount of mottling is generally regarded as undesirable and it is frequently believed to be a condition which may lead to rapid deterioration. A paper on this subject

entitled "Individual Hen Differences in Egg Shell Mottling and the Relationship of Shell Mottling to Clutch Size, Internal Quality and Weight Loss" by R. C. BAKER and R. CURTISS (*Poultry Sci.*, *ibid*, 904-8) stresses that mottling is a characteristic of the individual bird and shows little variability. Their conclusions that there is no significant correlation between shell mottling and weight loss or broken out quality are of practical importance.

Changing Egg Quality by Management

It is widely accepted that the chemical composition of the hen's egg shows little variation, but from some recently published papers it appears that small changes in the quality of the egg and in its weight can be achieved both by feeding and management—except for those variations the causes of which are already known, namely, green yolks, pink whites, etc. A number of papers deal with quality differences attributed to range compared with confinement rearing. One of these papers, "The Effect of Fat, Arsonic Acid and Range versus Confinement Rearing on Egg Quality" by H. L. ORR, E. S. SNYDER and S. J. SLINGER (*Poultry Sci.*, 1958, **37**, 212-4) gives an account of the effect of various diets with differing levels of fat and 3-nitro on the quality of the eggs from birds reared in confinement and on range. These authors found that the eggs from the range-reared stock were significantly smaller and of better quality than those from the birds reared in confinement. The effect of the 3-nitro was to lower egg quality and increase egg weight; the fat supplementation had no effect on egg quality or weight.

While the same differences with regard to egg weight have been reported by other workers, there has not been the same consistency in their results in connection with other quality characteristics. It seems from some recently published work that strain differences may affect the response of birds to different environment. Thus, in an account of "Seasonal Variations in Quality of Eggs laid by Caged Layers and Their Sisters on the Floor" by G. W. FRONING and E. M. FUNK (*Poultry Sci.*, 1958, *ibid*, 215-23) the authors demonstrate that the egg weight with the caged birds was consistently higher than that of birds housed on floors. But the percentage of thick albumen was consistently higher and the incidence of blood and meat spots greater in the eggs from the caged birds.

Much the same conclusions were found in an experiment on the "Quality of Eggs Laid by Caged Layers" by E. M. FUNK, G. FRONING, R. GROTTIS, J. FORWARD and Q. KINDER (Research Bull. 658, *Ag. Expt. Stn. Missouri*, March 1958) and they and several other workers have also reported the higher incidences of blood spots in caged birds compared with birds on deep-litter. But at least one paper—namely, "The Effects of Heredity and Certain Environmental Factors on the Incidence of Blood Spots in Chicken Eggs" by F. P. JEFFREY and M. PINO (*Poultry Sci.*, 1943, **22**, 230-4), draws attention to a reversal

of these conclusions. Therefore, although cage birds usually lay larger eggs of better quality and with greater incidence of blood spots compared with birds on deep litter, there is the possibility that strain differences may lead to some reversal of these characteristics. The recent work of Huston and his colleagues supports this. In an account of "Breed Differences in Egg Production of Domestic Fowl held at High Environmental Temperatures" by T. M. HUSTON, W. P. JOINER and J. L. CARMON (*Poultry Sci.*, 1957, **36**, 1247-54) they compare the performance of groups of three different breeds (New Hampshire, White Rocks and White Leghorns) reared under a constant temperature of 90° F with groups of the same breeds reared under normal conditions to 12 weeks of age. The former groups were subsequently carried in houses at a constant temperature of 90° F, and the latter housed under normal uncontrolled environment. Both the Rocks and the New Hampshires manifested a heavy drop in production in the controlled environment house compared with their sisters in the uncontrolled house. The White Leghorns, however, showed only a slight falling-off in production.

Varying Results from Feeding Nicarbazin

Feeding and the use of certain drugs have also been considered in relation to their effect on egg quality. Dealing with "The Effect of Nicarbazin on Egg Production and Egg Quality", R. C. BAKER, F. W. HILL, A. VAN TIENHOVEN and J. H. BRUCKNER (*Poultry Sci.*, 1957, **36**, 718-26) draw attention to the yolk blemish, reduction in egg production, decline in egg size and elimination of shell colour induced by heavy dosages of nicarbazin. Egg production was affected by levels in excess of .009 per cent, and egg shell colour by about the same level; yolk blemishes appeared with as little as .0015 per cent in the diet. However, in experimental work on "Egg Shell Colour and Egg Production in New Hampshire Laying Hens as Affected by Nicarbazin Medication" by D. K. McLOUGHLIN, E. E. WEHR and R. RUBIN (*Poultry Sci.*, *ibid*, 880-4) it was found that this anticoccidial drug at a level of .0125 per cent in the mash had a bleaching effect on shell colour and led to a depression in egg production, but no significant effects were noted in connection with internal quality or weight of the eggs from the treated birds. These different findings with different breeds suggest that strain differences may be of some magnitude. This is emphasized in a paper on "Strain Variation in Albumen Quality Decline of Hen's Eggs" by K. N. MAY, F. J. SCHMIDT and W. J. STADELMAN (*Poultry Sci.*, *ibid*, 1376-9). May and his co-workers draw attention to the egg quality recorded with a large number of eggs from 186 strains. They found differences in both the initial quality of the albumen and in the rate of deterioration over 7 days' storage at 55° to 60° F. Eggs with low initial quality generally had a lower rate of quality decline. Strain differences were apparent in the rate of decline in albumen quality, and the authors suggest that the characteristic is sufficiently important to warrant further

enquiries into the practicability of breeding for slow decline in albumen quality.

These several papers clearly demonstrate that environment can influence egg quality, but that strain differences may lead to some variation in the response to environmental change. Generally, it seems clear that birds in cages tend to have heavier eggs, a greater proportion of thick albumen and more eggs affected by blood spots than their sisters on deep litter. However, these tendencies are occasionally reversed and the varying responses and the findings of May and his colleagues emphasize our limited knowledge about the causes of variations in egg quality and the need for intensified research on a subject which is rapidly becoming one of great commercial importance to the poultry-keeper.

R.C.

CORRECTION

N.A.A.S. QUARTERLY REVIEW NO. 40

Milk By-Products for Animal Feeding—*page 255, lines 3, 4 and 5.*

The sentence beginning "It is perhaps better . . ." should be transposed to *line 13*, and follow the sentence which ends " . . . worth half as much as skim milk ".

Regional Notes

Copper Deficiency in Cattle in the Chipping Area of Lancashire

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COPPER DEFICIENCY was first described in Great Britain by Jamieson and Russell [5] in cattle on reclaimed heathland in Aberdeenshire and by Allcroft [1] in stock on peat land in Cheshire. Since then numerous reports have indicated that some degree of copper deficiency may occur on widely different types of land, although it appears to be more widespread on sandy and peaty soils.

The clinical effects vary according to the method of husbandry. Cows in beef herds which calve down in the spring and have themselves been copper deficient during pregnancy, have calves in which symptoms of the disease appear when they are two to three months old. In dairy herds symptoms are more often seen in the yearlings and two-year-old cattle. Calves in these herds spend much of their first year of life indoors, and usually receive proprietary calf foods that supply sufficient copper for physiological requirements. As yearlings or two-year-olds their source of food is pasture or hay gathered from home pasture, and it is during this period that symptoms of copper deficiency arise.

The chief symptoms observed are a gradual loss of condition; a stilted gait; discoloration of the hairs, which is most noticeable in the black hairs of the Friesian animal; a coat which retains the winter hairs throughout the summer and so appears harsh and rough; a grey ring of hair around the eyes and in the ears; diarrhoea and wasting which may terminate fatally due to secondary bacterial infection.

Factors contributing towards Hypocuprosis

Investigations into the problem of copper deficiency have shown that pasture copper levels are generally within the normal range, and molybdenum levels—though ranging from 1-19 p.p.m. have been classified as low or normal. The copper-deficient conditions are unlike the "teartness" in Gloucestershire and Somerset where pasture molybdenums may be as high as 100 p.p.m. Most instances of copper deficiency in this county are "conditioned", and caused by various factors in the diet interfering with the assimilation of copper. Recent investigations by Dick [4] and Wynne and McClymont [6] into factors affecting liver

copper storage have revealed a critical relationship between the copper, molybdenum and inorganic sulphate contents of the diet. At high levels of inorganic sulphate the molybdenum content becomes critical, and if fairly high could cause serious lowering of liver copper reserves. The level of molybdenum too (1.5 p.p.m.), is lower than had hitherto been considered critical in Britain. Allcroft [2] considered that other factors were also concerned in the development of hypocuprosis.

The soils of the Chipping area of Lancashire are mainly derived from boulder clay overlying limestone and millstone grit. In some parts areas of peat are found. It is a pastoral area producing milk, sheep and store cattle. Grassland improvement following heavy liming and slagging has been prominent in recent years. For some time reports had been received from the area of cattle losing condition whilst at summer pasture. Such cattle were often returned to winter feeding in poorer condition than when turned out the previous spring. Other farms were reported to be traditionally "poor cattle farms". It may be noted that "swayback" in lambs has been prevalent in the area except where pregnant ewes were appropriately treated with copper. Since 1955 investigations into the problem in cattle show that a conditioned copper deficiency existed in the area.

Part of the investigation of conditioned copper deficiency concerned two aspects:

1. The value of spraying and fertilizing pasture with copper sulphate to control copper deficiency.
2. Analysis of herbage to try to explain the condition in the light of the work of Dick (4) and Wynne and McClymont (6).

Some of the preliminary results obtained from this investigation form the basis of this report.

The work was done on two farms (A and B) and the results obtained on each farm are given below.

Farm A

During the summer of 1955 attention was drawn to very severe outbreaks of diarrhoea in spring-born suckling calves in a Galloway \times Shorthorn and Hereford \times Shorthorn herd grazing in an extensive area of reclaimed fell-land. Diarrhoea was accompanied by general loss of condition and gradual wasting away of the animals. Veterinary investigation suggested copper deficiency, and this was confirmed by analysis of blood samples which showed low copper levels ranging from 0.02-0.05 mg/100 ml of blood. Soil analyses indicated that the molybdenum level was high but copper was neither high nor deficient. Herbage analysis gave quite normal copper values of 9-10 p.p.m. of the dry matter, whilst molybdenum and inorganic sulphate contents were 2.3-5.0 p.p.m. and 0.56 per cent SO_4 of the dry matter respectively.

From these results it was decided to drench the calves periodically with an aqueous solution of copper sulphate that supplied approximately

2g of copper sulphate weekly. This treatment resulted in a marked improvement in growth rate and general vitality of the calves, and the gradual disappearance of visual symptoms of copper deficiency.

As drenching of large calves was a difficult, tedious and time-consuming process, the farmer was keen to have a simpler method of providing copper. A simple trial was conducted in 1956 to compare the effect of spraying a copper sulphate solution with spreading a copperized fertilizer that supplied the same amount of copper. Advantage was taken of this to study the seasonal trends in copper, molybdenum and inorganic sulphate contents of the herbage. The results for the dry matter of the herbage are given in Table 1.

Table 1

	Cut Number	Date	Copper	Molybdenum	Inorganic Sulphate
Control Area	1	14.5.56	<i>p.p.m.</i> 11.5	<i>p.p.m.</i> 3.4	<i>per cent SO₄</i> 0.68
	2	13.6.56	8.4	3.6	0.92
	3	23.7.56	7.2	4.3	0.86
	4	22.8.56	9.5	6.7	0.74
	5	19.9.56	10.0	5.4	0.94
5lb hydrated copper sulphate in 100 gal of water per acre.	1	14.5.56	19.8	2.1	0.53
	2	13.6.56	8.0	2.1	0.64
	3	23.7.56	7.2	3.7	0.59
	4	22.8.56	8.8	4.2	0.40
	5	19.9.56	8.3	4.4	0.64
5lb hydrated copper sulphate in 2 cwt compound fertilizer per acre.	1	14.5.56	14.2	1.9	0.70
	2	13.6.56	10.7	2.3	0.70
	3	23.7.56	8.5	3.0	0.77
	4	22.8.56	8.9	3.8	0.65
	5	19.9.56	8.8	4.3	0.90

The control area showed quite normal copper levels with little variation except possibly a slight mid-season drop and rise with the autumn flush. Molybdenum appeared to accumulate throughout the summer and the levels found were higher than those considered by Dick to be critical. All inorganic sulphate contents were higher than those of the diets used by Wynne and McClymont that caused serious lowering of liver copper values in sheep.

Spraying increased the copper content only for the first cut. The failure to maintain a higher copper level in the sprayed herbage was disappointing, but it is possible that the high copper content would be present at a time when most required by the calves, namely when they were eating a reasonable quantity of grass, and at a time when their natural liver reserves would have declined. Sufficient copper would probably be obtained from the herbage to carry them through to winter feeding when treatment with copper salts would be much easier.

The copperized fertilizer was not as effective as the spray on the first cut, but a higher level was present at the second cut. It is interesting to note that no calves grazing sprayed herbage in 1956 were affected by hypocuprosis. At the same time they had access to a box of copper-rich minerals, but individual consumption of these minerals was low. On an adjoining farm, owned by the same farmer where no spraying had been carried out, but where the calves had access to copper-rich mineral mixtures, symptoms of copper deficiency developed in many calves. Spray treatment, coupled with the provision of a box of copper-rich minerals appears to give a reasonable safeguard.

During the summer of 1957 a comparison was made of spraying copper sulphate solution at two levels—5 lb and 10 lb per acre—to see if the higher rate would increase the copper content for a longer period of the summer. Unfortunately, spraying was followed by a period of severe drought with resultant poor growth of pasture all the summer. Only two cuts of rather mature herbage were taken and the results expressed on a dry matter basis are given in Table 2. The results conformed to the pattern of those of the previous year.

Table 2

Copper Sulphate	Copper		Molybdenum		Inorganic Sulphate	
	1st Cut	2nd Cut	1st Cut	2nd Cut	1st Cut	2nd Cut
<i>lb per acre</i>	<i>p.p.m.</i>	<i>p.p.m.</i>	<i>p.p.m.</i>	<i>p.p.m.</i>	<i>%SO₄</i>	<i>%SO₄</i>
0	6.7	9.7	3.5	5.8	0.55	0.54
5	8.9	8.8	3.3	4.5	0.61	0.52
10	10.7	10.5	2.8	4.2	0.60	0.58

Calves at this farm were all suckling calves born away on a lowland arable farm where their dams were wintered on a diet of hay, straw pea-haulm silage and other arable by-products, but with little or no concentrates. During the first six to eight months of life these calves received only milk (low in copper) and herbage that had a composition of the type stated above.

It is felt that our studies of the herbage at least lend support to the conclusions of Dick, Wynne and McClymont concerning levels of copper, molybdenum and inorganic sulphate in the diet. Whilst other work will probably reveal other important factors, it is felt that analysis for these three constituents together with clinical examination affords some basis for the discriminate use of copper.

Farm B

The problem on this farm occurred in a herd of Friesian dairy cattle. It was confined mainly to one- and two-year-old cattle and a few of the older dairy cows. All calves were bucket fed and these received a good

deal of copper in the concentrates and milk substitutes used. They were nearly all autumn calves and were six months old when first put out to grass. For many years the farmer had noticed a gradual loss of condition of store cattle whilst at summer pasture, particularly those in their second and third summers. Symptoms were a stilted gait, tendency for the head to be carried low and for the hindquarters to sway as the animal walked. The black of the coat became dull grey and the animals retained their winter coats almost throughout the summer. A typical grey ring of hair giving a spectacled appearance was observed around the eyes. Most of the animals were brought indoors early in the autumn in a poorer condition than when turned out in the spring.

Clinical examination indicated copper deficiency, and herbage analysis gave the results for the dry matter shown in Table 3.

Table 3

	Copper	Molybdenum	Inorganic Sulphate
	<i>p.p.m.</i>	<i>p.p.m.</i>	<i>per cent SO₄</i>
Fresh Herbage . . .	8.0	6.3	0.64
Hay	6.0	2.1	0.24

The relatively high molybdenum compared with the copper and inorganic sulphate was again evident. Additional copper feeding was advised, and the cattle were dosed fortnightly with a solution supplying approximately 1½g of copper sulphate at each dose. A copper-rich mineral supplement was also placed in a bucket in the field. Consumption of minerals was at a high level—two to three buckets of minerals per 25 animals every four days. All stock improved rapidly in condition, and this improvement was maintained throughout the winter by using copper-fortified concentrates. During the summer of 1957 copper-rich minerals were again available in the field, but consumption was considerably less than in 1956. All stock have continued to thrive satisfactorily during the summer and autumn. The improvement in condition while on pasture was such that the owner was able to leave the animals out at grass for two months longer than usual.

A comparison of the problems at Farm A with Farm B, showed that at the latter the trouble occurred in older cattle particularly older stores, but with suckling calves at Farm A. Absence of the trouble during the first year at Farm B was probably due to the method of calf rearing, but after a prolonged period of feeding during successive summers and winters on herbage and hay of similar composition to that of Farm A, symptoms of hypocuprosis became apparent. The store cattle of Farm B were commonly wintered only on hay—often of the poorest quality. The copper content of samples at 6.0 p.p.m. of the dry matter was only 4.3 p.p.m. in the hay as fed. This very low level of copper, coupled with the comparatively high molybdenum and inorganic sulphate content

could well be a factor conducive to the onset of copper deficiency. It is not uncommon for hay to contain very low copper contents, and attention has been drawn to this by Ashton and Morgan [3].

Other Herds in the Area Benefit from the Treatment

Investigations made on the two farms A and B led to a number of visits to farms in the area. A number of other cases of unthriftiness in young cattle have been investigated, and veterinary examination, and hay and herbage analyses carried out. Clinical examination has suggested copper deficiency, and the analytical results all follow the same pattern as those previously described. Discriminate use of copper by drenching, spraying or copper-fortified concentrates has been advised, and general improvements in the health and condition of the stock noted. Farmers on whose farms the problems have been studied readily admit to a significant increase in the market value of the treated stock within a short period of copper administration. Whilst it is probable that new cases will be found in the future, it is proposed to continue investigations into factors causing copper deficiency in the Chipping area, and into methods of administering copper to various groups of cattle likely to suffer from copper deficiency. It is hoped to report on these further studies at a later date.

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Tractor Trends in the Eastern Region

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THE ADVISORY SERVICE in the Eastern Region receives fewer inquiries on tractors and field implements than on subjects relating to the installation and operation of barn machinery. This is not surprising, because East Anglia has a long tradition in the use of vast amounts of tractor power to plough the heavy lands deeply, and to perform the sequence of inter-row cultivation needed for potatoes and sugar beet. Long experience in this high utilization of tractor power has made farmers expert in choosing the correct machines, and operators skilful in getting the largest possible number of useful hours of work out of each piece of equipment, so probably the need for N.A.A.S. advice on these matters was thought to be less necessary than on relatively new subjects such as grain drying and handling, and the milling and mixing of feedingstuffs.

Lately, however, more and more questions are being received on field operations and even on tractors, and there seem to be several reasons for this increase. One is that the cost of tractor operations now accounts for quite a large part of the whole farm expenditure on producing crops; and a saving in the work of tractors and in the labour needed to operate them may be more important than a saving in fertilizer or seeds. Another is that farmers find the maintenance and replacement of track-laying tractors more expensive than that of wheeled tractors, and they have been investigating the possibility of extending the use of wheeled tractors. This is a new line of thought in a part of the country with a tradition in the use of track-laying tractors. On the other hand, some farmers at present using wheeled tractors are giving increasing thought to the possible effects of the compaction of soil by pneumatic tyres.

Inquiries are being received on the technique of sub-soiling to break up pans which may have been formed by tractors, and which are thought to be interfering with drainage and plant growth, and also on the selection of tractors and wheel equipment of a type less likely to compress the soil. Already in some places where pneumatic tyres were previously used, cage wheels, open-type wheels and even spade-lugged wheels are to be seen. This development, or more truly, this reversal of trend is perhaps more likely to spread in the farms of the Eastern Region than in some other parts of the country, because fields are large and fewer roads intersect the fields.

Improving Work Routines

Many of the inquiries being received on the economics of tractor operation ask for help in deciding how long a tractor ought to be kept before it is sold or traded in as an exchange for a new one. From discussion

with farmers, the Machinery Department is collecting information on these points and is able to help a little in problems relating to the probable life of machines and the incidence of repair bills. The subject of method study of field operations is also in the mind of farmers just now, because a saving achieved by improvement of routine usually brings a saving in tractor hours as well as a saving in man hours. Farmers are quite happy to make simple timings of some of their tractor work, such as the cycle of operations involved in using a mounted muck-loader to move the manure from a heap and to put it on to a spreader. If they find that the routine of filling the shovel of the fore-loader, manoeuvring the tractor to discharge the load on to the spreader and then taking the tractor back ready to fill the shovel, takes longer than a minute, they are prepared to see whether the spreader is correctly placed in relation to the edge of the heap, whether the prongs of the shovel are set at the depth of only one fork-load below the top of the heap, whether the tractor wheels are free from slipping, and indeed whether the shape of the yard is right.

With this same desire to improve work routines, new layouts of work for ploughing are being tried, to reduce idle tractor running. The benefits of one-way ploughing with a reversible plough even in large fields are being discussed, and in round-and-round ploughing, pioneered in East Anglia, new methods of marking the field to give an accurate layout, with a minimum of sharp curves with the plough in work, are being investigated.

Which is the Best Machine for Inter-Row Cultivation?

Inquiries concerned with the importance of choosing the best type of tractor rather than with keeping down the running expenses are often connected with problems of inter-row cultivation. In the 1930s the demand for row-crop tractors in East Anglia was met very largely by imported tricycle-type machines with very high ground clearance so that mid-mounted and forward-mounted implements could be used. Not all farmers think that modern British tractors, made in a compact form and designed primarily for implements to be attached at the rear, are the best for sugar beet and potato work. Very many American row-crop tractors over 20 years old are being kept in working order, at considerable expense, because the farmers cannot find a British-made tractor which they consider to be a true substitute. In this connection, the N.A.A.S. takes every opportunity to devise, collect and disseminate any hints on operation likely to improve accuracy of work with rear-mounted implements. The importance of mechanizing row-crop work becomes greater every year, and methods must be quick and accurate.

Obtaining and Maintaining a Good Tilth

East Anglian farmers realize more than most the value of a good tilth for seedbeds, and experiments at Boxworth Experimental Husbandry

Farm have shown that late sowing on a good seedbed can give better results than early sowings on a poor one, provided the varieties of wheat grown are right for late sowing. When potatoes are to be harvested mechanically, it is important that the potato land shall not contain clods at planting time. These do not matter so much if the crop is to be hand picked, provided that at seed time there is some fine soil to go with the clods. For mechanical harvesting, clods must be broken down in the seedbeds, and care taken that they are not allowed to form again during subsequent inter-row cultivation, or when tractor-drawn machines are taken over the land for spraying. Farmers believe that a good tilth can be prepared only by putting the soil into the right condition for it to be weathered for as long as possible at a season of the year when freezing and thawing, and wetting and drying can have their best effect. They have found from experience that a machine-made tilth lacks many of the qualities of weather-made tilth. It is to get the land ready for weathering early that such a large force of tractors is maintained on many farms.

Fen farmers have liked track-laying tractors for the lightness of their pressure upon the soil. Moreover, since the tractor is riding on the unploughed land, what little compaction does take place is in a layer soon to become part of the furrow slice and broken up. A wheeled tractor, on the other hand, usually has one front and one rear wheel running in the furrow bottom at just the level for creating a plough pan, and the tilt of the tractor adds weight to wheels probably ballasted already to help grip. It is the possibility of compaction at this level in the soil that is causing farmers to wonder whether heavily ballasted pneumatic-tyred tractors are harmful at ploughing time.

Just as the farmers are anxious to get a good tilth, so are they also anxious not to destroy it once it has been made. Therefore, they always have in mind the effect of wheels on soil at seeding time and at the time of inter-row cultivating. At seed time, a heavy pneumatic-tyred tractor drawing a drill over the soil leaves a compacted track in which coulters do not penetrate as deeply as in the part of the land free from compression by tractor wheels; it is possible to use a tine, fixed behind the tractor wheel to break up the soil cap, but this sometimes disturbs the seedbed undesirably. In inter-row work, compressing by tyres can offset some of the good achieved by the implements.

Fen soils are not abrasive and wear of crawler tractor tracks is slow. Nevertheless, the possibility of using more wheeled tractors is being seriously investigated. In some other parts of the Region, notably Essex and Bedfordshire there are soils which are very abrasive.

The brick earths and silts of East Anglia often lose their stability because of the partial breakdown of the iron compounds which, with the organic matter, help to stabilize soil structure. Tractor wheels can then puddle the surface of the soil and cause bad aeration. However, this is something which can often be put right by harrowing, but it is a factor that must be watched.

